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THE FREEDOM OF VOLUNTARY ASSOCIATIONS

WHEN Lord Beveridge published his report on "Voluntary Action" in October 1948, a supplementary volume was promised, entitled "Evidence for Voluntary Action". In this volume, now published*, are collected reports on investigations by Mass Observation on the friendly societies, voluntary services and on some aspects of charity in Great Britain, tables embodying the results of a survey made by Research Services, Ltd., in July and August 1947, memoranda on the finance of voluntary action and memoranda submitted by organisations, as well as by individuals, on special topics. The result is a miscellany of information, of varying merit, some formal or statistical, some discursive and, more rarely, critical. Apart possibly from Mr. A. F. Wells's memorandum on urban and rural amenities, which gives a survey of the work of the amenity societies, including the National Trust, which is in itself particularly useful in view of the steadily increasing threats to the scenic heritage and flora and fauna of Britain, and Mr. R. Wilson's notes on the future of voluntary action, the supplementary volume contains little for the scientific worker that he will not find in Lord Beveridge's original book.

In the meantime, however, the importance of voluntary action has been made abundantly plain, and its implications for the man of science have been repeatedly stressed. The Nuffield Foundation, in its third report last year, recorded its unshaken belief in the continuing value of private venture, and continued: "The welcomed increase of State support for learning and research does not lessen the need for voluntary enterprise; neither does it decrease the importance of alternative sources of support if the principle—fundamental to a free and democratic society—is to be upheld that 'there should be room for more than one opinion and for more than one means of putting that opinion to the test' ". Bertrand Russell has also made a similar point in his Reith Lectures: "Without facilities provided by a government or a university, few men can achieve much in modern science. The conditions which determine who is to have access to such facilities are therefore of great importance. If only those are eligible who are considered orthodox in current controversies, scientific progress will soon cease, and give way to a scholastic reign of authority such as stifled science throughout the Middle Ages."

That passage from the Reith Lectures was promptly quoted by the Nuffield Foundation in its fourth report, and without implying that the private foundations are themselves examples of the "creative minorities" to which Mr. Arnold Toynbee, in his "The Study of History", attributes the genesis of all civilized progress, the trustees rightly observe that private funds, in that they are not subject to the audit of the majority, do ensure that the "creative

* The Evidence for Voluntary Action: being Memoranda by Organisations and Individuals and other Material relevant to Voluntary Action. Edited by Lord Beveridge and A. F. Wells. Pp. 344. (London: George Allen and Unwin, Ltd., 1949.) 16*s.* net.

minority" gets at least a first hearing and the chance of commanding wider support. There is not, indeed, in Great Britain any real reason as yet to fear that the audit of the majority is exercised oppressively; but the growing dependence of the universities and of research institutions generally in Britain upon State endowment, to which the recent issue of the "Returns from Universities and University Colleges in receipt of Treasury Grant" bears striking witness, has led men of science to view the future with concern. Sir Edward Appleton, speaking in Edinburgh on October 3, rightly said that the substantial provision for research in Great Britain is largely associated with great freedom for the scientific worker, and that in British universities such freedom is complete. Sir Edward commented on the fact that provision for research is made by way of grants and not by way of contracts, and it will be remembered that in his presidential address to the Royal Society in 1946, Sir Robert Robinson suggested that the universities should refuse to accept contracts from Service Departments to which conditions were attached restricting free publication of the results. Happily, most awards, such as the research fellowships offered by Imperial Chemical Industries, Ltd., and other firms, are entirely free from restrictions as to the precise topic of research and publication. Nevertheless, the universities themselves, in view of their increasing dependence on Government grants, are apprehensive of their position; and while the recent report from the Committee of Public Accounts shows that the Government regards the present arrangement as providing the means for reconciling the maintenance of university autonomy with the need for ensuring that the moneys voted are well spent in the public interest, the growing appropriation for the universities fully justifies the Committee's plea for more effective means of securing adequate Parliamentary control over this large expenditure of public money.

For that very reason scientific workers cannot remain wholly indifferent to the question of voluntary action in its wider context. The closer scrutiny of the expenditure of large sums of public money which may rightly be demanded is unlikely to be abused if there is in the public mind a clear understanding of the importance of freedom of investigation and of the place of voluntary enterprise in society. These are points made by Mr. Wilson in the memorandum already mentioned, and in the debate in the House of Lords on June 22 on voluntary action for social progress, and they apply equally in scientific research. The traditional justification of voluntary social work, writes Mr. Wilson, has lain in its capacity to pioneer and in its flexibility. Neither may depend quite so much on voluntary organisations in the future; but, although experience during and since the War has shown that in certain conditions Government departments can act with creative imagination on a vast scale, it is early yet to say that major changes in the philosophy of government are being translated into administrative forms. It is difficult at the moment to judge how far some of the rigidity that characterizes national administration is due to ministerial policy rather than to administrative weaknesses; but evidence on the scientific side suggests that the organisation is becoming too set, in spite of the view expressed both by the Select Committee on Estimates and Sir Edward Appleton in evidence before it that the final form should not be determined for years to come.

On this point Mr. Wilson is somewhat optimistic, but the second factor to which he refers, namely, the drying up of traditional sources of money, is one to which scientific foundations have repeatedly referred in recent annual reports. Nevertheless, as Mr. Wilson observes, neither of these social changes affects the real basic contribution of voluntary social work to the life of the community. It is to-day less true in science than in some other fields that, without going so far as to pioneer, the amateur who had creative social ideas and the ability to work them out in a small way in the first instance was able to make things happen. Such contributions, by providing a link between the private citizen and social responsibilities, distributed the onus of preserving and developing the social structure over a much wider constituency than if it had been the field of officials and elected representatives only. The danger of placing social responsibility entirely in the hands of trained administrators is that there is no independent body of citizens who understand the issues involved in the light of their own experience.

The professional man might well reflect that some of our difficulties to-day in regard to nationalization and the National Health Service might have been avoided had professional organisations been a little more imaginatively alive to the issues, and undertaken on their own initiative some of the pioneering work which would have assisted in the formation of public opinion on what was really involved. Voluntary organisations—and among them professional associations—have most important educational functions, and the growth of public institutions and the changing financial status of voluntary organisations do not in any way diminish the need for voluntary social responsibility in Great Britain if the gap between officialdom and public opinion is to be bridged. Mr. Wilson sees scope for large developments in the use made by official bodies of amateur advice and experience; and with the increasing and intelligent use of advisory bodies linking the independent part-time worker and the official administration, he thinks that the community has little to fear from the development of public social administration. He puts his finger, indeed, on one weakness—the meagre development of co-opted membership of local authority committees—and he would like to see something less cumbersome than mere party discipline evolved as the basis of co-ordination and direction in local government administration to make such co-option possible.

The basic question, however, is that of finding part-time workers, and of the three problems—the use of the part-time volunteer in official administration, the finding of money, and the finding of

time—the finding of time is the most important. Given that men and women who wish to serve can be freed to do so, they should be able to solve the other two problems; the danger is, as Roy Lewis and Angus Maude have shown in their recent study of the "English Middle Classes", that present tendencies will destroy both the means and the desire to serve.

The debate on the subject in the House of Lords ranged over many matters as relevant to the scientific worker's right of investigation and utterance and to voluntary action in the service of science as in that of social progress. Even Lord Samuel's plea in opening the debate that government inquiry into the whole question of voluntary action would strengthen and encourage the work of voluntary associations in general, as well as provide opportunities for the right use of leisure, is not altogether outside this issue. Scientific men too readily overlook the debt which science owes to the work of the local societies. It would be an ill day for science if it disdained altogether the services of such amateurs and volunteers, however difficult it may be for them to contribute to the advance of certain fields of physical science. The Conference of Delegates of Corresponding Societies, now a regular feature of British Association meetings, and the accounts of work done under the Council for the Promotion of Field Studies given at the meeting of the Association at Newcastle upon Tyne, provided recent evidence that there is still a place for the amateur.

Much was said in the House of Lords debate on the vital contribution which voluntary effort makes to a healthy democratic community. Lord Selkirk maintained that the test of democracy now is whether or not we could produce statesmen who prefer liberty to power, and that it is a fundamental element of liberty that we should be able to associate freely for limited purposes. A State has an inherent tendency to become static, and any political organisation that is to flourish must possess a large measure of adaptability. That is no less true of a professional association or a research institution, and Lord Nathan's eloquent tribute to the initiative which voluntary action has taken in what are now the great social services should equally remind the professional man that it is not in the social sphere alone that voluntary service has blazed trails and schooled men and women in the practice of democracy. London, Lord Beveridge reminded us, owes its 'lungs' to voluntary action, and it is not only in such spheres as a national health service that voluntary action, by bringing in the human touch, can help to prevent undue rigidity.

Voluntary action, Lord Beveridge pointed out in the same debate, is also needed to render service which it is not easy to secure otherwise. Much of his speech was concerned with the charitable trusts which are tied by obsolete conditions, and his proposals on this point drew a detailed reply from Lord Pakenham for the Government. The debate, however, was worth while for the emphatic declaration with which Lord Pakenham first affirmed the Government's conviction that voluntary associations have rendered, are rendering and must be encouraged to render, great and indispensable service to the community. In the view of the Government, democracy without voluntary exertion and idealism loses its soul.

Lord Pakenham pointed out, however, that in spite of its concern to promote voluntary action, the State must be very careful about the manner in which its help is given, and he laid stress upon the need to avoid standardization if voluntary action is to remain free from external control and to retain its power to express the ideals of a minority, to move ahead of general opinion, to experiment, and to modify universal regulations in the interests of a particular case. But while anxious to strengthen and encourage voluntary effort, Lord Pakenham did not favour the idea of a Voluntary Services Grants Committee on the lines of the University Grants Committee, or giving to the Lord President of the Council, who is already responsible for reviewing voluntary action in the academic and scientific fields, a similar responsibility in that of social services. He concurred with the view of the National Council of Social Service that the present departmental basis is more satisfactory.

No more specific or emphatic pronouncement as to the value of voluntary service could well be expected from the Government, and the debate should also serve a useful purpose in emphasizing the limits of State action. The latter can never provide more than the conditions or opportunity of living.

Even academic freedom is never an isolated phenomenon, as Prof. M. Polanyi remarked in an article on "The Foundations of Academic Freedom" published two years ago, but which deserves a fresh examination. The tolerance of academic freedom by the State, he points out, is not enough to-day. On the modern scale, institutions of higher learning and higher education can be upheld only by public subsidies, and governments recognize to-day that to give such support is a proper public responsibility. The danger from State aid arises when there is no strong and independent body of academic and professional opinion, enjoying both the respect and understanding of the general public, and able to resist any encroachment on academic autonomy which may arise through conflict between sectional interests and those of the cultivation of learning and investigation for its own sake.

Prof. Polanyi stresses the value of permanent academic appointments as a safeguard of academic autonomy, though he recognizes that self-government of the universities is no more a safeguard against corruption of academic freedom than is self-government of a profession a guarantee against inertia and resistance to reform. Fundamentally, his argument rests upon the same basis as that of Lord Beveridge in reference to the social sciences. We must ensure that there exist in society to-day and to-morrow the means whereby the talented investigator has access to the material resources for research he needs, untrammelled by other duties, by orthodoxy or by prescription of topics.

Those needs will not invariably be met within the walls of a university, and we have to ensure variety of opportunity as well as adequacy of resource. We can only do this so long as the universities and professional institutions are alive to their responsibility. Within them there must be freedom for the variety of opinion, for the "creative minority" among all those who respect the standards of professional conduct and intellectual honesty which are fundamental in the search for truth. The vigour of academic and professional life depends on the existence of such groups, and on the readiness of their members, within the safeguards and security which academic and professional institutions afford, to think deeply on their special studies; and also, in a wider professional and social context, to consider how best their technical contribution to the solution of a particular problem can be rendered to the Government and to the society of which all are members, and if necessary to put their opinions to the test of experiment.

We have as yet scarcely begun to visualize the contribution which the professions could offer to the better ordering of society, or to the ways in which their knowledge and experience could be put most effectively at the service of society. There are many problems of organisation here to be studied, but the attention now being focused on voluntary action should remind us how urgent is the need for all professional associations to give unceasing attention to the whole issue. Powerful forces of the modern world are threatening the security and independence of the professional classes as a whole, and if unchecked may render them incapable of such potential services or even of supplying the leadership they have done in the past. Professional freedom can only exist in a free society; the principles underlying it are those on which academic freedom also, and the most essential liberties of society as a whole, are based. The defence of freedom rests above all on the willingness of professional men and women to use their professional—and voluntary—associations to great and unselfish ends.

CHEMISTRY IN CANADA

A History of Chemistry in Canada

Compiled by C. J. S. Warrington and R. V. V. Nicholls. Pp. x + 502 + 13 plates. (Toronto: Sir Isaac Pitman and Sons (Canada), Ltd., 1949.) 4.50 dollars.

IT is clear from this book that chemistry has played a great part in the development of Canada. Indeed, according to Lash Miller, the first colonist of New France was a chemist, Louis Hébert; upon lands given by his descendants in the city of Quebec stands Laval University at the present day. Moreover, it was in the Séminaire de Québec, in 1720, that the first public instruction in chemistry in this part of North America was begun. There is much picturesque historical detail of this kind, new to the European reader, in the authoritative work under notice; but the book is equally valuable for the picture it gives of the economic and industrial development of Canada, viewed against a chemical background. Almost every important field of applied chemistry has been treated in this triple aspect, with the help of numerous specialists working under the auspices of the Chemical Institute of Canada.

The book opens with the statement that a thread of metal runs through the whole fabric of Canadian history. With Cabot and Frobisher and Cartier this thread was of gold, although the imagined gold and diamonds that Cartier (who was obviously neither a chemist nor a mineralogist) brought back to France turned out to be iron pyrites and quartz! In later days, by a kind of inverted alchemical transmutation, this thread has changed into silver, copper, iron, nickel and uranium. From metals the story passes to chemical by-products of smelting, and thence to other subjects of great scientific, economic and industrial importance. Fertilizers, mineral products, chemicals from coal, natural petroleum and derived chemicals, products of the electric furnace, of electrolysis, of wood, of agriculture and the sea, medicinal and fine chemicals, explosives, oils, fats and waxes: all these and still other fields of applied chemistry are treated in turn from the Canadian point of view, and set forth with statistics, maps and other illustrative material.

In this way a realistic picture is gradually elaborated of Canada's impressive natural resources and of their development to date, as seen by the chemist. The extent of these resources may be illuminated by a few statements selected from the book at random. Enormous subterranean deposits of common salt extend over an area of three thousand square miles in the province of Ontario alone; the province of Quebec contains, at Asbestos, the largest asbestos mine in the world; in coal reserves Canada stands next to the United States; three out of every five newspapers in the world are printed on Canadian-made paper. This wealth of natural materials is accompanied by bountiful natural sources of energy. The expanding use of electrical energy is particularly noteworthy. During the past hundred years the five-fold increase in material output per worker in North America is ascribed chiefly to the extensive industrial application of electricity as a motive power and in electrochemical reactions. In this respect, the hydro-electric power of the Niagara and Shawinigan areas assumes a special importance. Canadian activity and enterprise find a further expression in the fact that Canada consumes more petroleum products per head than any other country. At present more than 90 per cent of these oil supplies is imported; but current developments in Canadian oilfields are gathering momentum, notably in Alberta.

An account of chemistry and public services in Canada describes numerous research organisations, including the National Research Council, formed in 1916, with its many divisions and sections, illustrated by such diverse undertakings as the Atomic Energy Project at Chalk River, Ontario, and a Prairie Regional Laboratory at Saskatoon. The flourishing state of Canadian chemistry finds a further reflexion in the detailed accounts of chemical teaching and research in the universities and other institutions.

In brief, this book affords an impressive description of Canada's natural resources seen from the point of view of the chemist; of their development from early days to the present time; of the leading men responsible for this development; and of the striking vitality of Canadian chemistry in the industries, research organisations and universities of that great country.

JOHN READ

POMOLOGY

Cherries

By Norman H. Grubb. Pp. viii+186+28 plates. (London: Crosby Lockwood and Son, Ltd., 1949.) 30*s.* net.

The Plums of England

By Dr. H. V. Taylor. (Agricultural and Horticultural Series.) Pp. viii+151+32 plates. (London: Crosby Lockwood and Son, Ltd., 1949.) 30*s.* net.

THE author of "Cherries" rightly states that the planning of a satisfactory cherry orchard is a "difficult venture". Factors such as shelter, freedom from frost and the character of the soil must first be taken into account. The selection of suitable varieties involves consideration of their time of ripening and of a suitable mixture of varieties in order to ensure effective pollination; the best sorts of rootstocks must also be chosen. All these points are dealt with in the first part of the book. Are the traditional English methods of growing cherries the best, or would the growing of trees on shorter legs in cultivated ground show any advantage? These and other controversial matters are discussed in the chapter dealing with orchard management. Though comparatively brief, the section of the book dealing with the culture of cherries will be very useful to all growers of this fruit.

At every point, however, whether we are considering suitable soils, frost, disease resistance, rootstocks or pollination, we are confronted with the necessity for choosing the right varieties and for knowing that they are true to name. Almost inevitably in the course of propagation and distribution varieties are occasionally wrongly named, and it is very desirable that there should be records of the correct description of every named variety. Systematic pomologists in the past have not always agreed in their nomenclature, and there has been a need for their descriptions to be checked, revised and brought up to date owing to the introduction of new varieties. This is the work on which Mr. N. H. Grubb has been engaged for more than thirty years, and the results are seen in the last three-quarters of this volume. Here he discusses the characters which may be used in the identification of varieties, and shows how cherries may be classified in groups from consideration of their sweetness, colour of juice and season of ripening. The identification of any one variety in a group may be completed by reference to the detailed descriptions which comprise the remainder of the book. Some 240 varieties, including synonyms, are listed, and in every case the description is that made by the author himself; about 170 varieties which are growing in the collection at the East Malling Research Station are described very fully. All cherry growers and systematic pomologists will be grateful for the publication of this valuable book.

Though Dr. H. V. Taylor, owing to his other activities, has not lived in such intimate contact with his subject, yet from his own observations and from information collected from other sources he has compiled a book which all those who are interested in plums will be glad to read and to keep for reference. Part 1 of the book includes sections on the botany of plums, the origin of old varieties and the breeding of new ones. Attention is given to all aspects of plum growing, such as rootstocks, pollination, soils, nutrition, pests and diseases, while other sections include statistics relating to the production of plums in different parts of England and a chapter on the uses of plums for dessert and for processing in various ways. The identification of varieties is then considered, and a classification based on fruit-colour, shape and ripening period is given. Part 2 consists of descriptions of about 150 different kinds of plums grown in England. These are not full pomological descriptions but are a useful guide to the chief characteristics of the varieties, and, read in conjunction with the classification scheme, they will be a help in the identification of any variety. Much of the information in this book, as the author acknowledges, can be found in other publications; but it is useful to have it assembled in one volume.

Both these books have good bibliographies and are illustrated by colour photographs of fruit. Though in a few cases the accuracy of the reproduction of the natural colours may be questioned, the plates on the whole are excellent, being both beautiful and also valuable aids to the identification of varieties. The book on cherries also contains a number of illustrations in black-and-white, including photographs showing the characteristic habit of growth of some varieties of cherry trees.

G. T. SPINKS

CLASSIFICATION OF THE DRONGOS

A Revision of the Bird Family Dicruride

(Bulletin of the American Museum of Natural History; Vol. 93, Article 4.) By Charles Vaurie. Pp. 199–342. (Philadelphia, 1949.) 1.75 dollars.

THE family Dicruridæ, or drongos, has its headquarters in the oriental region, though there are a few species in the Ethiopian and Austro-Papuan regions. The drongos were placed by Sharpe and Hartert with the birds of paradise, but more recent writers, including Mayr, consider they are more nearly allied to the orioles. According to the author, the phylogeny of the family is fairly simple, and he has reduced the number of genera to two, *Chætorhynchus* with twelve tail feathers and *Dicrurus* with ten. Many of the characters used by former workers as generic characters, such as the shape and structure of the tail, shape of the bird and presence or absence of a crest, Mr. Vaurie finds are very variable and unsuitable. He considers the Papuan mountain drongo *Chætorhynchus papuensis* the most primitive member of the family, and in the genus *Dicrurus* *D. ludwigii* and *D. atripennis*, both from Africa, are the least specialized.

The ashy drongos were formerly divided into three species, a grey, a dark-coloured and one with white facial markings. But after examining a large series, Mr. Vaurie comes to the conclusion that they belong to one species, and this is supported by the fact that in different parts of the range he has found what he considers are intermediates. The races of the greater racket-tailed drongo *D. paradiseus* are an interesting study in the development of the crest. Birds inhabiting Borneo and adjacent islands are crestless; specimens from the southern part of the Malay Peninsula and Sumatra have developed a bushy tuft or a very short crest. The crest in the Javanese birds is well developed, but does not reach its full development until the most northerly part of the bird's range is reached in the Himalayas and Hainan.

This is a valuable review, and Mr. Vaurie is to be congratulated on his careful work.

N. B. KINNEAR

A 30-MILLION VOLT SYNCHROTRON FOR MEDICAL USE

THE installation of the first of the two 30-MeV. synchrotrons designed for the Medical Research Council has been completed at the Royal Cancer Hospital, London, and the apparatus has been in satisfactory operation for four months. A formal opening of the laboratories in which it is installed was held on July 5, and was attended by representatives of the Medical Research Council, Atomic Energy Research Establishment, Ministry of Health, and other interested bodies. Some of the technical detail of the instrument has already been described in *Nature*[1] by Fry, Gallop, Goward and Dain, who were responsible for its development.

In conventional X-ray apparatus, electrons are accelerated by a large potential difference between cathode and anode of a discharge tube. For potentials above about 1 million volts the construction of this type of X-ray tube and generator involves many difficulties. The electron-synchrotron as installed at the Royal Cancer Hospital, essentially a development of the betatron, consists of a large alternating-current magnet, and its mode of action is similar to that of a high-tension transformer, the familiar secondary coil being replaced by an evacuated glass annulus, the 'donut', into which electrons are fed from an electron gun. The magnetic field is so shaped that, as the flux increases, the electrons are both accelerated and held near a circular orbit in the 'donut'. In a betatron this constitutes the sole method of acceleration, but in the synchrotron under consideration only the initial acceleration, up to about 4 MeV., is obtained in this way. At this energy an electron has a velocity close to that of light (0·992c at 4 MeV.), and any further increase in energy is reflected in a change of mass rather than velocity. It is therefore possible to arrange an electric accelerating field to vary in synchronism with the rotating electrons. This field provides the final stage of acceleration in the synchrotron and is obtained from a quarter-wave radio-frequency resonator formed into a hollow cylinder through which the electrons pass. The electrons in the apparatus in question make of the order of two million revolutions in the 'donut', and consequently a small energy increment of 10 electron-volts per revolution is sufficient to increase their final energy to the desired amount. By switching off the radio-frequency accelerating voltage before the peak magnetic field is reached, the electron orbit shrinks on to a target mounted in the 'donut', thereby producing X-rays.

The instrument installed at the Royal Cancer Hospital is of compact design, the magnet having eight C-shaped yokes contained within a cylinder some 4 ft. in diameter. It weighs about three tons. The peak magnetic field is 10,000 gauss, the coil current then being approximately 160 amp. The magnet is excited continuously from 50-cycle mains by a resonant circuit carrying a reactive power of some 1,500 kVa. The electrons are injected, just after zero field, for about 5 micro-seconds at 10 kV. It is hoped that improved gun design will later enable higher injection voltages up to 100 kV. to be used, yielding

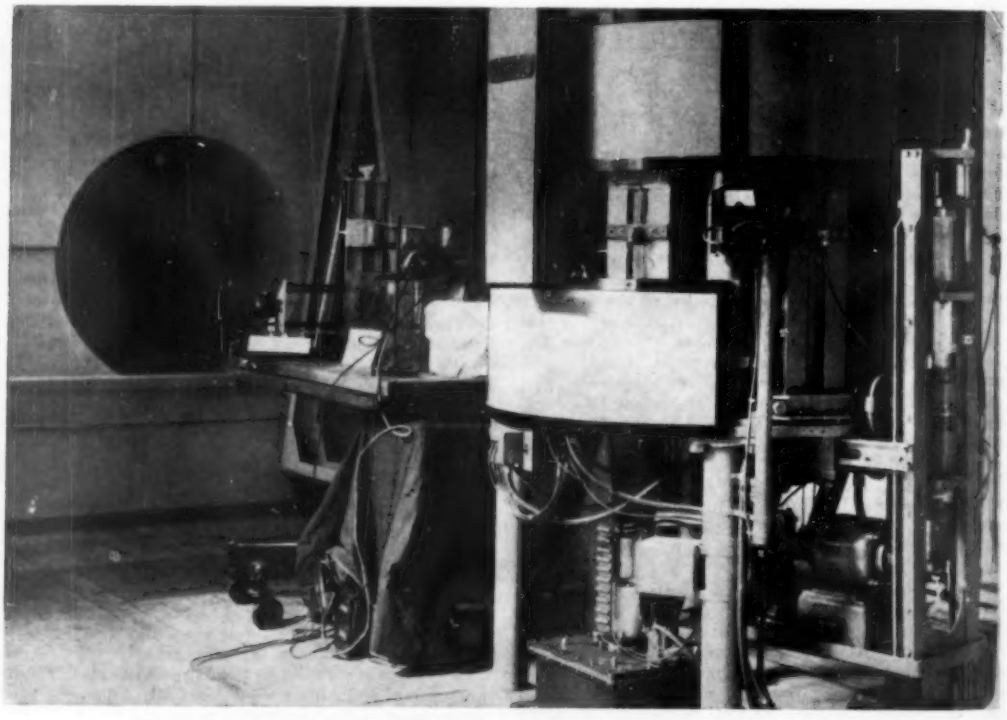

Fig. 1. The 30-MeV. synchrotron at the Royal Cancer Hospital, London

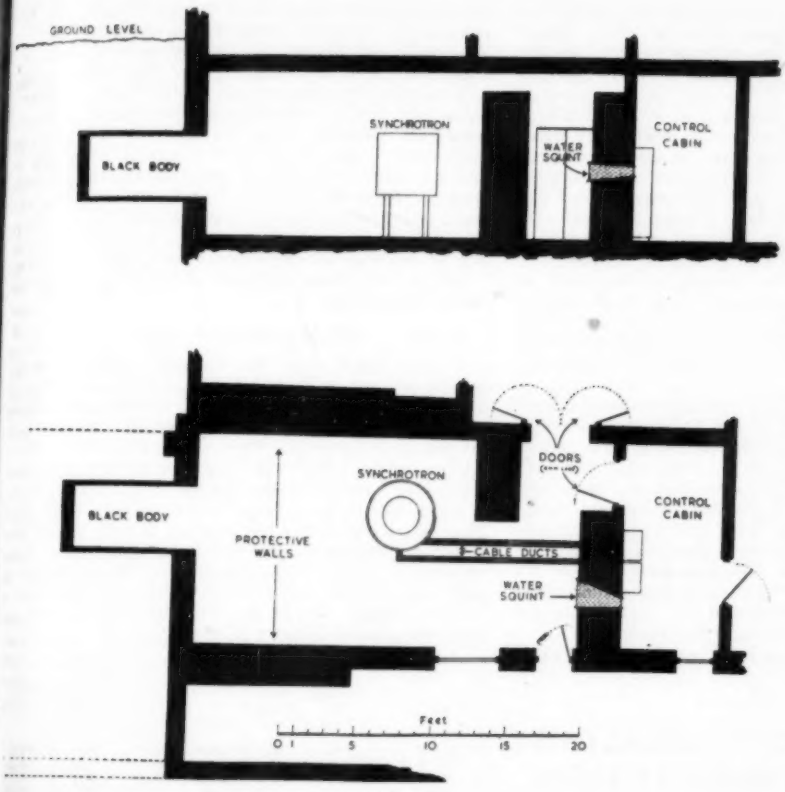

Fig. 2

higher X-ray outputs. The radio-frequency resonator is of 'Faradex' (dielectric constant = 80), on to which a conducting silver coating has been fired. The accelerating gap is burned by an arc. The resonator is so short that it need not be moulded to a circular shape, as is necessary when using air as dielectric, and is excited at 488 Mc./sec., some 30 watts peak power being supplied. The target in this machine is a tungsten wire, approximately 2 mm. diameter, mounted vertically in the 'donut'. The instrument as installed is shown in Fig. 1.

This, the first synchrotron in the world specifically devoted to medical research, will be used to investigate the many problems and possibilities of medical use of X-rays and electrons in the 30-MeV. region, and is of great radiobiological interest apart from its possible medical applications. It forms part of the equipment of the Medical Physics Department of the Royal Cancer Hospital under the direction of Prof. W. V. Mayneord, and is integrated into the general work of that Department on the applications of nuclear physics in medicine.

In order to ease the problem of providing protection from the radiation produced, the apparatus has been installed in a basement laboratory, though owing to new mechanisms of absorption of radiation which become operative above about 1 MeV. and the natural canalization of the beam, the problem of protection is not as difficult as might at first be supposed. The X-ray beam is fired into a 'black body' cut, at a depth of about 8 ft., in a mound of earth 20 ft. long. Protective walls, 3 ft. thick, of a special concrete brick are provided at the side and rear of the synchrotron, and the machine and any patients or apparatus may be watched from the control cabin through a 3-ft. long tank of water sealed into the rear protective wall. A plan and elevation of the laboratories are shown in Fig. 2. Preliminary measurements at 21 MeV. indicate that the measures taken are likely to prove adequate, but further observations at higher X-ray outputs (the present value is approximately 1 r./min. at 1 metre at 22 MeV.) must be awaited.

Preliminary work (in the press) extending up to 50 MeV. carried out by Prof. Mayneord and Dr. J. H. Martin using betatrons, synchrotrons and linear accelerators in both Great Britain and the United States has provided much useful information and materially assisted the planning of the laboratories and research programme.

It has been found that by the use of ionization chambers of suitable design and materials, measurements of 'intensity' in röntgens may satisfactorily be made up to 25 MeV., though the ranges of the secondary electrons in materials resembling tissues are so great as to call for caution in any attempted correlation of ionization measurements and biological or clinical effects. On the other hand, the length of the tracks of the electrons produced by these high-energy quanta lead to an energy absorption at a depth of a few centimetres in tissue which is several times greater than that at the surface. It should therefore be possible to treat deep-seated lesions more satisfactorily than at present, since the limit of dose which may be given to a tumour has often been set by the tolerance of the skin of the patient. The usefulness of the synchrotron as a therapeutic weapon will, however, depend on an accurate knowledge of the distribution of energy absorption within the body of the patient. Given this knowledge, considerable improvement of present techniques can be hoped for. Without it, very great damage could unwittingly be inflicted on the patient. It is already clear from preliminary measurements that the distribution of energy-absorption in the body will depend very much on the precise geometry employed and that the problem is more complex than at lower energies. Preliminary observations have also demonstrated the

induced radioactivity of animal tissues subjected to beams of X-rays at energies above 17 MeV. These and many other effects are receiving careful study.

Physical studies will be followed by investigations of the biological effects of the rays on a number of organisms, animals and specific tissues, and finally it is intended that the synchrotron be used in the treatment of patients suffering from cancer in sites at which the special properties of the rays are considered to have advantages. The medical investigations will be undertaken in collaboration with Prof. D. W. Smithers, director of the Department of Radiotherapy in the Hospital. To this end it will be necessary to investigate by the use of models the amount of radiation reaching various parts of the body and to devise suitable equipment to direct and control the amount of X-rays administered. It will probably, therefore, be several months before treatment can commence.

The scientific development of the apparatus has been largely due to a section of the Telecommunications Research Establishment, Great Malvern, now part of the Atomic Energy Research Establishment, Harwell. The magnet and much of the electrical gear have been designed and built by the English Electric Co., Ltd., Stafford, in consultation with the Telecommunications Research Establishment, which is also responsible for the electronics. Development costs of the unit have been borne by the Medical Research Council, and the Royal Cancer Hospital has undertaken the cost of providing the necessary laboratories.

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PRODUCTION OF RADIOACTIVITY IN ANIMAL TISSUES BY HIGH-ENERGY X-RAYS

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Introduction

THE photo-disintegration of atomic nuclei by high-energy X-rays is well known; but there seems previously to have been no record of the production of radioactivity in animal tissues. In view of the obvious radiobiological and medical importance of any such phenomena, we have carried out preliminary observations on rat tissues exposed to beams of X-rays from the Royal Cancer Hospital synchrotron. It was found that there is no difficulty in demonstrating induced activity in the tissues, and we have therefore attempted to find out what elements are responsible for the activity, the order of radioactivity induced, and to assess its biological significance.

Experimental Procedure

A full-grown dead rat was placed in the X-ray beam, which passed from head to tail down the length of the animal. In initial experiments the animal was placed as near the target as possible, but later it was removed to a distance of approximately one metre so as to allow of more accurate geometry and dosimetry. The times of exposure varied from five minutes to one and a half hours in beams, the dosage-rates of which ranged from 0·5 to 1·0 r./min. as measured in a 6-mm. wall 'Perspex' chamber. The ionization currents measured were corrected to 'electronic equilibrium conditions' according to the strict definition of the röntgen. The beam, which was monitored continuously with both condenser chambers and direct-reading dosage-rate systems, remained constant to a few per cent during the exposures. After exposure, the animal was removed and its activity measured with calibrated thin-wall Geiger-Müller counters coupled to conventional scaling circuits. Activities having half-lives less than about one minute, or more than a few hours, would not be detected in our experiments. The maximum counting-rates obtained were of the order of twenty times background.

Experimental Results

It was found that the induced activity decays rapidly at first with a half-life of the order of two minutes, leaving a longer-lived component. This result has been confirmed on a number of occasions, involving experiments with three separate animals and counters of different designs applied both to the surface and inserted into the rat.

Experiments have been performed at 17, 21 and 24 MeV. At 17 MeV. the activity is very small, but counting-rates of the order of twice background were obtained. At 21 MeV. the activity is considerable, and most of our experiments have been performed at this voltage. At 24 MeV. the activity is some 50 per cent greater than at 21 MeV.

Expt.	MeV.	Dosage-rate (r./min.)	Time of exposure (min.)	Observed counting-rates			Ratio of activities
				Total	2-min. activity	20-min. activity	
1	21	0·6	30	1100	980	120	8·1
2	21	0·6	30	1100	980	120	8·1
3	21	0·6	90	2000	1690	310	5·5
4	24	0·4	30	1620	1370	250	5·5
						activity/r./min.	
5	21	0·4	30	590		1475	
6	21	0·6	30	770		1280	
7	21	0·8	30	1000		1250	

An example of the decay curve obtained by exposure of a 470-gm. rat for 90 minutes in a beam of dosage-rate 0·6 r./min. at one metre from the target is shown in Fig. 1. The curve, plotted semi-logarithmically, reveals two half-lives of 2·1 and 20 min. respectively, agreeing with the known half-lives of oxygen-15 and carbon-11 [1]. Both these isotopes are positron emitters which might be expected to result from (γ, n) reactions in oxygen-16 and carbon-12 respectively. The observed threshold near 17 MeV. is also in accord with the published values for oxygen-16 [2]. It may be noted that oxygen and carbon constitute approximately 70 per cent and 12 per cent respectively of soft animal tissues. The accompanying table also illustrates the results of experiments under various conditions of excitation.

Experiments 1, 2 and 3 show how the relative importance of carbon and oxygen activities change with time of exposure, the long-lived carbon gradually building up in the longer time. A theory, similar to that of the production of radioactive substances in neutron beams, may easily be written down. The high rate of counting in Exp. 3 is due to the greater efficiency of the geometry used in this case.

Exp. 4 demonstrates the relatively greater carbon activity at 24 MeV. as compared with 21 MeV., and deserves closer study in view of the complexities of

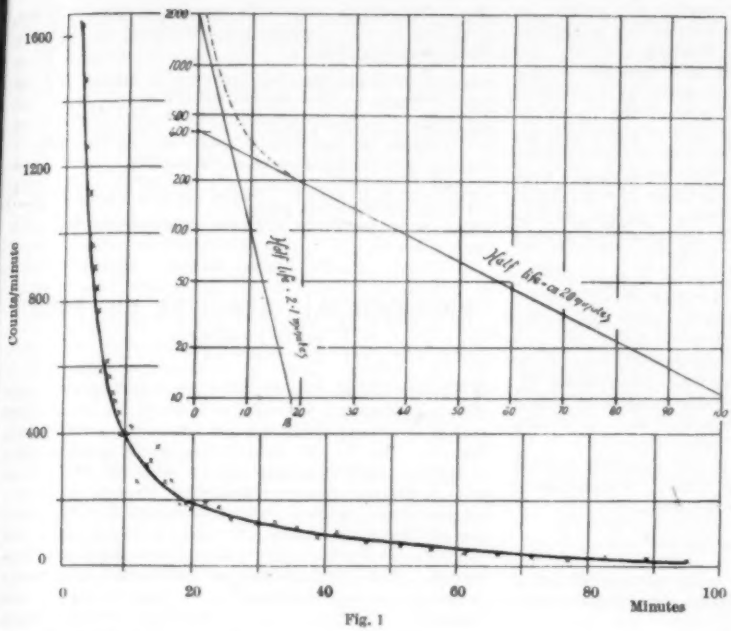


Fig. 1

variation of cross-section with energy already reported by other workers in this energy region[2].

Exps. 5, 6 and 7 demonstrate the approximate proportionality of short-lived activity with dosage-rate.

For comparison, experiments were next carried out on water and ice. Water is activated in the beam and decays exponentially with a half-life of 2·1 min. Fig. 2 shows the decay of activity of a block of ice of approximately the same dimensions as those of the rat placed in the beam and tested in identical circumstances. It was found that the absolute value of the short-lived activity is the same as that of the rat within the limits of error. This result again suggests that oxygen and carbon constitute the main activities in the region of half-lives observed by us. Further experiments may well reveal activities due to other elements.

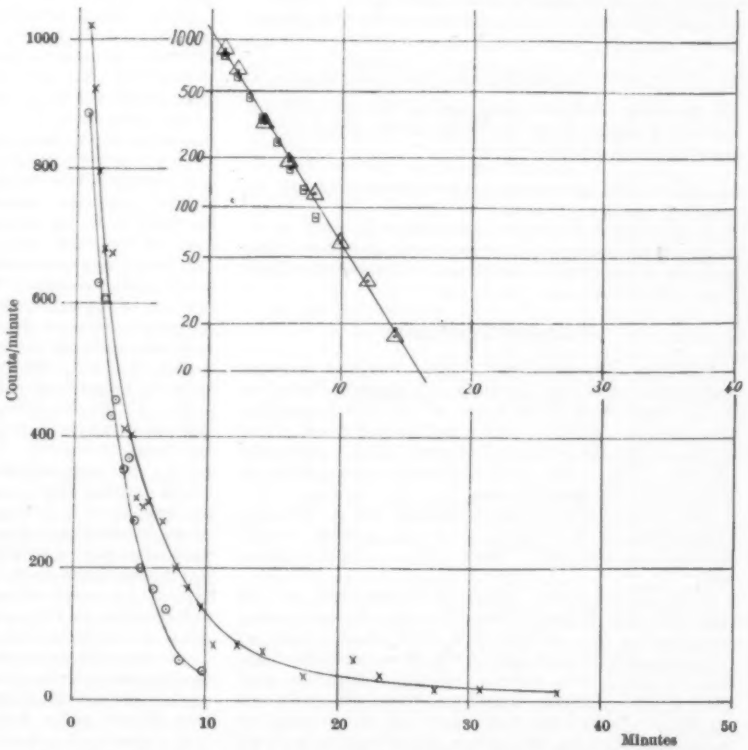
Theoretical Consideration of Results

It is of interest to attempt to calculate the order of magnitude of cross-sections for the reactions concerned. It may readily be shown that, at equilibrium, the number N_∞ of disintegrations per second per c.c. of radioactive nuclei produced by the radiation is given by

$$N_\infty = \frac{n\rho\sigma L}{M},$$

where n is the number of active quanta per cm.^{2}/sec., ρ the density of the activated isotope, L is Avogadro's number, M the mass number, and σ the required cross-section.

Two main difficulties arise: (*a*) the determination of the absolute number of disintegrations per second per c.c. from the experimental observation of counts per second under complex geometrical conditions; and (*b*) the estimation of n, the number of quanta above the threshold. We have attempted to determine these numbers as follows.



○ — ○ —, 170 gm. ice; × — × —, 160 gm. rat; △ — △ —, 2 min. activity of rat; □ — □ —, total activity of ice

Fig. 2

(*a*) To calibrate the experimental equipment, a solution of phosphorus-32 of known concentration was frozen into a block of ice of approximately the same size and shape as a rat and counted under identical conditions. This procedure is legitimate inasmuch as the maximum energy of the electrons from phosphorus-32 is equal to that of the positrons from oxygen-15, and the annihilation radiation from the latter is negligible. In this way we estimate that after an exposure of 30 min. in a beam of 0·6 r./min. produced at 21 MeV., the activated oxygen is disintegrating at a rate of 35 disintegrations per second per c.c. of tissue; that is, $N_\infty = 35$.

(*b*) Assuming the distribution of energy in the *Bremsstrahlung* spectrum to be that calculated by Heitler[4] for heavy elements, and knowing the energy flux per röntgen at energies up to 30 MeV.[5], we can calculate by graphical integration the fraction of the total ionization due to quanta above a given threshold. By reversing the process, it is then possible to calculate the total energy flux in ergs/cm.² sec. above the threshold, and so the number of quanta.

We find in this way that the number of quanta having energies greater than 16·3 MeV., the threshold for oxygen, in our beam of 0·6 r./min. is

$$n = 1{\cdot}37 \times 10^8 \text{ quanta/cm.}^2 \text{ sec.}$$

If we base our argument upon an experimental determination of energy distribution in the spectrum[6], we find $n = 1{\cdot}27 \times 10^8$.

Assuming that 70 per cent by weight of tissue is oxygen, $\rho = 0{\cdot}70$ gm./c.c., and inserting $L = 6{\cdot}06 \times 10^{23}$ and $M = 16{\cdot}0$ we calculate, using the Heitler data,

$$\sigma = 0{\cdot}9 \times 10^{-28} \text{ cm.}^2 \text{ for a } (\gamma, n) \text{ reaction in oxygen-16.}$$

By precisely analogous arguments, but allowing for the lower efficiency of counting of the lower-energy particles from carbon, we find

$$\sigma = 5 \times 10^{-26} \text{ cm.}^2 \text{ for a } (\gamma, n) \text{ reaction in carbon-12.}$$

It is clear that these are mean cross-sections at 21 MeV. for the quanta above the respective thresholds, and are of the order of magnitude estimated for other (γ, n) reactions.

Biological Significance

We may calculate from these data the rates of absorption of energy in tissue (*a*) directly from the X-ray beam, and (*b*) by virtue of the disintegrations. One röntgen delivered to 1 gm. of tissue corresponds to an energy absorption of 93 ergs. At a dosage-rate of 0·6 r./min., the rate of energy absorption is, therefore, 0·93 ergs/gm. sec.

The rate of absorption of energy due to the disintegrations from oxygen, assuming a mean energy per disintegration of 0·7 MeV., is $0{\cdot}4 \times 10^{-4}$ ergs/c.c. sec.

Even allowing for carbon disintegration, we see that the rate of absorption of energy during irradiation due to the activation is only of the order of 0·01 per cent of that due to the more usual mechanisms of absorption, namely, electron recoil and pair production. Unless, therefore, there are unknown strong short-lived reactions and high 'resonances', it is unlikely that the production of radioactive isotopes in the tissues investigated by us would contribute materially to the biological effects of high-energy X-rays in them. By analogous argument it is unlikely that short-lived materials remaining at the end of irradiation will contribute appreciably to the total energy absorption.

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BIOLOGICAL ASPECTS OF RIVER POLLUTION

BIOLOGICAL aspects of river pollution were discussed at a joint session of Sections D (Zoology) and K (Botany) of the British Association on September 5. Dr. B. A. Southgate, in introducing the subject, described briefly the varied types of domestic and industrial wastes discharged to surface waters. In industrial districts the sewage treated at municipal sewage-disposal works often contains a high proportion of waste liquors from manufacturing processes. Some constituents of these are incompletely removed during treatment of the sewage. For example, effluent from a works treating sewage containing gas liquor usually contains small quantities of thiocyanate and polyhydric phenols.

The extent to which surface waters in Great Britain are polluted varies very greatly from one district to another. In some rivers the effect of the pollution on the flora and fauna is mainly that caused by the addition of nutrient substances; on the other hand, some rivers, and many estuaries, receive such large quantities of organic matter and poisonous substances that only a few species of the more resistant organisms can survive. The effects of polluting substances in streams depend markedly on the temperature. Increase in temperature increases the rate of oxidation of organic matter by bacterial action and reduces the concentration of oxygen in solution in the water; in very polluted streams conditions may become wholly anaerobic in hot weather. The toxicity of some poisonous substances—for example, cyanide—is increased by a rise in temperature and also by a reduction in the oxygen tension in the water, which is itself reduced by a rise in temperature.

Mr. F. T. K. Pentelow discussed the effects of metallic poisons and of oxidizable organic matter on the fauna of streams. A striking instance of poisoning by copper salts occurred in the River Dove, where waste waters from the pickling of copper are discharged into a tributary. Immediately below the point of discharge the concentration was about one part of copper per million; at a point thirty miles downstream this had been reduced only to about 0·1 p.p.m. Above the tributary 178 invertebrate animals, belonging to thirty species, were collected from unit area of the river bed. A short distance below the confluence the numbers in a corresponding area were seventeen animals of two species; eight miles downstream there were twenty-one animals of six species; and thirty miles below the discharge there were 108 animals of ten species. In the reaches affected by the pollution the species present were the same as those in the unpolluted river; this appears to be typical of pollution by metallic poisons.

The effects of pollution by oxidizable organic matter are usually quite different. Immediately below the point of discharge, and before decomposition has begun, the effect on the distribution of the flora and fauna (including fish) may be very small. Lower down the stream, where decomposition is proceeding actively, with a lowering of the oxygen tension and deposition of sludge, the normal fauna is replaced by a typical community consisting of 'sewage fungus', Tubificidæ, and larvæ of Chironomidæ of the *plumosus* type. Farther downstream Chironomidæ of other groups and leeches—particularly *Herpobdella octoculata*—appear. At this stage sewage fungus disappears and with it the black deposit of sludge on the river bed. The numbers of Chironomidæ and Tubificidæ then decline, and *Asellus* becomes a characteristic member of the fauna. The next stage, farther still downstream, is usually marked by the appearance of pulmonate molluscs, after which the animals of the community normal to the unpolluted river replace those of the polluted stretch. At this stage fish are usually found.

Prof. W. H. Pearsall pointed out that, from the botanical aspect, investigations of river pollution have been concerned mainly with attempts to employ different plants as indicators of the stages of organic pollution and of subsequent oxidation. He illustrated the sensitivity of these tests by referring to the effects of small concentrations of organic matter on the algal population of a stream. The products of oxidation of organic matter in flowing water, mainly carbonates, nitrates and phosphates, have a great effect on the luxuriance of plant growths and thus lead to accumulation of organic muds, even though the polluting liquids themselves may lack visible turbidity. The animal population is also affected by the presence of these muds and the anaerobic conditions they may introduce.

The principal botanical problem associated with such pollution is, however, connected with the large quantities of compounds of nitrogen and phosphorus discharged to surface waters in sewage effluents and their loss to the national economy. Methods by which these materials can be recovered and used in agriculture are thus very important. One possibility would be to pass the effluent through shallow lakes containing such plants as *Elodea*, which would grow very rapidly under these conditions and which might be harvested and used as a green manure. Another possible method of utilization might be to pass the sewage effluent through water meadows containing such plants as *Sparganium* or *Glyceria*, which could be grazed by stock or possibly harvested and used for making silage.

Mr. H. Jones described the pollution of the rivers of North Cardiganshire—particularly the River Rheidol—by compounds of lead and zinc leached from spoil banks of mines. The active polluting substances are lead sulphate and zinc sulphate, which are formed by oxidation of the sulphides at the surface of the spoil banks. In the drainage area of the Rheidol, mining on a large scale ceased in 1922; the river at that time was almost barren, containing only small numbers of Algæ and Bryophytes, with occasional insect larvæ and Crustacea. By the summer of 1923, however, the river contained representatives of all the usual groups of aquatic animals with the exception of Mollusca and fishes; at this time *Callitriche verna* and *Ranunculus aquatilis* appeared in the river. Although mining has generally ceased, pollution still occurs, however, during periods of flood. Intensive work has been undertaken at University College, Aberystwyth, to investigate methods by which the river could be restored to its natural condition. It was shown by E. W. Jones that addition of calcium carbonate and superphosphate in comparatively large amounts to soil impregnated with the metals greatly improved the growth of vegetation by reducing the concentration of available lead and zinc below the toxic level. Trees of several species were successfully grown in the affected areas, the two most resistant of those tried being birch and pine. Best results were obtained when trees about six feet high were transplanted, and when they were planted in pockets of uncontaminated soil. During recent years there has been a remarkable improvement in the condition of the River Rheidol, which has now been extensively re-colonized by aquatic plants, particularly *Callitriche intermedia* and *Glyceria fluitans*. Migratory trout and salmon are now found in the river, and freshwater trout have been successfully introduced.

INDUCTION OF MUTATIONS

At the recent Newcastle meeting of the British Association, the Botany and Zoology Sections jointly held a symposium on the artificial induction of mutations. Dr. P. T. Thomas (Aberystwyth) reviewed the work on the induction of cytoplasmic changes by the action of chemical agents. He pointed out that when such changes are induced in lower organisms, as in yeasts, they often appear to be relatively stable, indicating that the cytoplasm in these organisms is incompletely subordinated to the control of the nucleus. In higher organisms, on the other hand, cytoplasmic changes are of limited duration (*Dauermodifikation*), although they may last through several sexual generations.

Two important conditions must apparently be satisfied in order to induce cytoplasmic changes, particularly in higher organisms. (1) The external agents must act for a relatively long time, because, unlike the nuclear genes, the genetically important cytoplasmic determinants are thought to be in a chemical equilibrium. (2) The influence of the nucleus on the cytoplasm must be at the minimum—a condition which can be attained by keeping the nucleus arrested in its mechanically active phase, while at the same time allowing cytoplasmic synthesis to proceed.

Dr. J. M. Thoday (Sheffield) discussed the influence of oxygen on radiation-induced chromosome structural change and indicated the advances that have been made towards elucidating the sequence of events involved in the formation of chromosome structural changes initiated by ionizing radiations. While these advances have been largely concerned with the later phases of the sequence, he thought it possible that the discovery of the influence of oxygen might lead to knowledge of some of the active chemical substances involved in the earliest phases. This would help to bring radiation work into line with that being done on chemical mutagens.

Dr. Thoday then outlined the target theory of radiation breakage, and presented results, obtained with *Vicia faba*, to demonstrate that the target theory stands up to some of the criticisms that have been levelled against it. However, the target theory can only account for the variation in yield of aberrations

with progress of the mitotic cycle on one of two assumptions, neither of which seems valid. It thus becomes necessary to suppose that the effect of a particle within the target volume is not to produce a complete break, but to initiate a potential break which may lead to separation immediately if mechanical conditions, etc., are favourable, may remain latent as in *Trillium* metaphases, or may lead to restitution without separation ever occurring. The proportion of potential breaks that separate and become primary breaks (detectable through their influence on the frequency of exchanges) will vary according to the physiological state of the cell, which itself can be altered by radiation. Dr. Thoday presented evidence that, in *Vicia*, oxygen greatly increases the yield of aberrations obtained with a given dose of X-rays, but does not affect, or affects very little, that obtained with a given dose of α-rays, and pointed out that this parallels the effect of oxygen on the production of hydrogen peroxide from water by these radiations. It thus seems likely that hydrogen peroxide or some related radicals play a part in the formation of aberrations; but it is impossible to say whether hydrogen peroxide is the agent producing potential breaks, or whether it affects the yields indirectly by some effect on the physiological state of the cell that alters the frequencies of separation of potential breaks formed in some other way. Dr. Thoday also mentioned some preliminary results that seem to show *E. coli* to be less sensitive to X-rays if irradiated in the absence of oxygen. The effect of oxygen may therefore be quite general.

Dr. T. G. Carter (Edinburgh) considered the induction of mutations in small mammals. Following the original work of H. J. Muller on flies, the probability that radiations can also induce mutations in man has led, during the past twenty years, to numerous detailed studies on the effects of X-rays on mice and other small mammals.

At least four visible inheritable defects have been induced in mice by radiations, all by Paula Hertwig in Germany during 1938–39. Their main features were lethal anæmia, fusion of the toes (syndactyly), loss of toes (oligodactyly) and a nervous disorder (kreisler). A fifth visible defect, microphthalmia, combined with lack of pigment in the coat, may also have been induced by the radiation. Invisible hereditary defects in mice, manifesting themselves as semi-sterility, were first reported by Snell in the United States in 1935; he induced them by both X-rays and neutrons from the California cyclotron.

These studies were intensified in the United States during the War and extended to include gamma-rays from radioactive materials, and neutrons from atomic piles. The main object of the war-time work was to provide a basis for rules to safeguard the health of workers on atomic projects and to ensure that they should not become sources of undesirable radiation-induced hereditary traits which might then spread through the population during succeeding centuries. Conclusions drawn from this work are summed up in the following sentence from an article by R. D. Evans in *Science* of March 1949. "From the appropriate mathematical theory, and the experimental data now available, it seems safe enough to conclude that no detectable increase in hereditary abnormalities is likely to result, even after many generations, if a small fraction of the population receives daily doses up to 0·1 roentgen per day."

The paper by Dr. C. Auerbach (Edinburgh) described some of her work on the production of mutations by chemical means, which was first achieved during the War. Following on the suggestion of Dr. J. M. Robson, of the Pharmacological Department of the University of Edinburgh, it was decided to try the effect of mustard gas for mutagenic activity. This suggestion was based on observations of the similarity between mustard-gas burns and X-ray burns. Since it was known that the typical action of X-rays is due to effects on the chromosomes, it seemed possible that the same might be true for the action of mustard gas. In addition, Dr. Robson had found that vaginal epithelium of mice which had been treated with a weak solution of mustard gas failed to respond to œstrogen by the usual proliferation, an indication that mustard gas inhibits cell division. The first experiments of Robson and Auerbach in the winter of 1940 on *Drosophila* showed that doses which were not lethal to the flies had a sterilizing effect on both males and females. During the first days after treatment, some progeny were produced, but many of the eggs laid by treated females or inseminated by treated males failed to hatch; afterwards, with a sufficiently high dose, both sexes became completely sterile. This agreed well with observations on X-rayed animals. It indicated that after mustard gas, as after irradiation, sterility has two separate causes: (1) inhibition of cell division in the gonads so that no replacement of expended gametes takes place; and (2) embryonic death after treatment of either parent. Embryonic death after X-radiation is due to chromosomal disturbances in the treated gamete; possibly the same might apply to mustard gas.

The first crucial test for the mutagenic action of mustard gas was done early in 1941, using the so-called ClB test, whereby the percentage of sex-linked lethal mutations can be accurately determined. In untreated laboratory stocks, mutations to sex-linked lethals arise spontaneously in less than one per cent of gametes; in the controls to the first ClB test, there were 0·3 per cent spontaneous lethals. In the treated series, the frequency of sex-linked lethals was seven per cent. In subsequent experiments with bigger doses, even higher mutation-rates were obtained. There could thus be no doubt of the mutagenic efficiency of mustard gas; mutation-rates of this order had previously been obtained only with ionizing radiations. Further analysis showed that mustard gas produces all the genetical effects which occur after X-radiation: visible and lethal gene mutations, small and large deletions, inversions, translocations, etc. Small deletions form about the same proportion of mustard gas-induced lethals as of X-ray-induced lethals. Large rearrangements, on the other hand, which require two independent chromosome breaks with subsequent reunion of broken ends, are considerably less frequent after mustard gas than after X-rays. This shortage is particularly pronounced for translocations, that is, exchanges of pieces between chromosomes. We do not yet know whether mustard gas is less efficient than X-rays in breaking the chromosomes, or whether it interferes with the reunion of broken ends so that fewer rearrangements can be recovered. A second difference from X-ray effects is the high percentage of mutations which first appear as mosaics. This and other observations of a similar nature suggest that mustard gas, in contrast to X-rays, sometimes has a delayed mutagenic effect, causing mutations not in the

treated chromosomes themselves, but in their descendants.

Chemically, mustard gas belongs to the group of the so-called mustards, several of which were found to be mutagens of great power. The inhibition of mitosis by the mustards is used in the treatment of certain types of malignant disease. The same is true for urethane, which likewise was found to be a mutagen. Phenol, or perhaps a contaminant of phenol, has given high frequencies of mutations in experiments by Hadorn and his collaborators. Formalin, mixed with the food of *Drosophila*, is a highly effective mutagen. The fact that one weak, but decidedly positive mutagen, mustard oil, occurs naturally in *Brassica* plants raises the question whether naturally occurring mutagens have played a part in evolution.

THE CENTENARY OF FINLAND'S INSTITUTE OF TECHNOLOGY

By Sir ALFRED EGERTON, F.R.S.

A STATUTE issued in 1847 prescribed the foundation of such schools in Finland as would provide "youths who wish to have a career in Industry with an opportunity for all the necessary training". The Technical School founded in Helsinki was opened on January 15, 1849. So was born the present Finland's Institute of Technology, which has just celebrated its centenary.

The Institute has experienced several phases of development. In 1872 the Technical School became a Polytechnic School with five departments, architecture, civil engineering, mechanical engineering, chemical technology and surveying. In 1879 the School became a Polytechnic Institute admitting only matriculated students, and in 1908 its name was changed to "Finland's Institute of Technology" and it was placed under the control of the Ministry of Trade and Industry. Administration is in the hands of the Rector, who is chairman of an Administrative Council. There is also an advisory body appointed by the Government. Diplomas are given in architecture and in engineering (civil, mechanical, electrical, chemical; wood technology, mining and metallurgy, and technical physics). The syllabus is drawn up on the basis of a course of four and a half years. The examination is in two parts, a preliminary or intermediate examination in the basic sciences, followed in the second period by specialized training and a diploma thesis. Practical training in industries with which the Institute is related is included in the course. Opportunity for postgraduate studies are provided and lead after a considerable period of study to the degree of doctor of technology. The diploma courses are designed on the principle that in a country like Finland with a comparatively small population (3·8 millions) the need for technical experts is limited compared with the larger countries, and so the aim is to give students a good general theoretical basis in engineering or architecture, with opportunity for advanced specialized training in a wide choice of subjects.

The Mechanical Engineering Department of the Institute is the largest, with about 580 students. The Department has four separate sections: mechanical engineering, ship-building, aeroplane construction and textile engineering. In chemical engineering, the stress is laid on the basic training in chemistry and in engineering; practical experience is gained in works rather than attempting to operate chemical plant in the Institute, which seems a wise procedure. There is a separate and very active Department of Wood Technology relating to Finland's major industry, divided into the sections, chemical, mechanical and paper, and well equipped with appliances for testing and treatment of wood. The Chemistry Department is well known for researches (of Prof. G. Komppa and others) on the chemistry of terpenes. The Department of Architecture has also a great reputation; Prof. J. S. Sirén is the present head.

Teaching is provided in Finnish and in Swedish. There are fifty-two professors on the staff of the Institute and 2,200 students (of whom nearly 200 are women). All students enrolled belong to the Students' Corporation, which promotes the intellectual efforts of its members and assists their finances. Within this Corporation, each Department of the Institute has its own students' guilds based on the subjects studied and their special interests, such as the choir, the orchestra, the athletic society and the girl student club. These free activities of the students have been helpful in preparing them for public life; there is much innate talent in the Finnish students, and the standard of achievement in their many activities is remarkably high.

The main building of the Institute dates from about 1875; but it has been largely rebuilt and greatly extended by the addition of new buildings (for example, the Mechanical Engineering Laboratory). The principal building, with its fine hall and council room, was considerably damaged during the Second World War, but has now been repaired; the new chemical laboratories were on view on the occasion of the centenary. The present site is pleasant; it opens on to a wide space leading to one of Helsinki's many quays. Looking to the future, however, plans are afoot for buildings on an altogether new site.

The Institute has trained many of Finland's leading men—industrialists, architects, engineers and men of science—and it was no wonder that the celebration of the centenary was a momentous occasion in Helsinki. The main festival was held on September 13 in the hall of the University and was attended by President Paasikivi. General Mannerheim was present also. Addresses were handed to the Rector by representatives of many institutes of technology in foreign countries, including the Imperial College, London, and the Victoria University, Manchester; Prof. Wright Baker represented the Victoria University. It would not have been consistent with Finland's contribution to the arts if this gathering in honour of its great centre of science and technology had taken place unaccompanied by music; not only were those who attended delighted by the music of Sibelius, but there was also the magnificently trained students' choir.

On the next day, a ceremony was held in the hall of the Institute for the conferment of degrees: Dr. K. T. Compton (U.S.A.), Prof. A. Engelund (Denmark), M. A. Perret (France), Sir Alfred Egerton (England), Prof. F. Vogt (Norway), Prof. H. Kreüger and Prof. R. Woxén (Sweden), and Prof. M. Roš (Switzerland) received the degree of doctor of technology *honoris causa*, along with Prof. A. I. Virtanen and other distinguished men of Finland.

Finnish affairs are largely in the hands of those who have been distinguished in technology or the academic field, and the conspicuous virility and efficiency in the industry and the culture of Finland may arise partly from this circumstance. They also owe much to the courage and energy of the Finnish people. The open-hearted hospitality towards the many guests on the occasion of this festival was also characteristic.

OBITUARIES

Prof. C. L. Fortescue, O.B.E.

Prof. C. L. Fortescue's death on September 22, only three years after his retirement from the chair of electrical engineering at the Imperial College of Science and Technology, London, came as a shock to his many friends and former colleagues and staff. He was born in 1881 and educated at Oundle School and Christ's College, Cambridge, where he obtained a first class in the Mechanical Sciences Tripos. He played an active part in school and College life, was a keen oarsman and reached the 'trial eights' while at Cambridge. This keen interest in student activities and particularly rowing never diminished, but probably increased during his later years, and he was rarely away from the river when Imperial College crews were racing.

On leaving Cambridge he spent some years at Messrs. Siemens dynamo works and as instructor in electrotechnics and applied mechanics at H.M. Torpedo and Gunnery Schools, Portsmouth. During 1911–22 he was professor of electrical engineering at the Royal Naval College, Greenwich, and during this period, in addition to his academic and administrative duties, he carried out experimental work connected with wireless telegraphy during the First World War.

In 1922 he was appointed professor of electrical engineering at the Imperial College of Science and Technology, London. He was the third to occupy this position since 1885, the two previous occupants being Profs. W. E. Ayrton and T. Mather. During the whole of the twenty-four years that he was professor and head of the Electrical Engineering Department he was indefatigable in his work for the College and never seemed to begrudge the long hours he spent in the Department. He was always accessible to the students and ready to help them in any way that was possible. As a lecturer and teacher he was probably more successful with the advanced and postgraduate students than with those in the earlier years, who, in many cases, found his methods of dealing with electrical engineering somewhat difficult to appreciate. He will, generally speaking, be remembered at the Imperial College for his very strenuous work in connexion with the teaching of the subject of telecommunications at the undergraduate stage and the development of facilities for study and research in this subject for postgraduate students.

This development was so successful that it can be stated that the Electrical Engineering Department of the Imperial College provided a more thorough course of education in the subject of telecommunications than any other college or university in Great Britain, and students from all over the world were attracted both to the undergraduate and postgraduate courses.

As a professor of the University of London, he took very seriously the many duties which fell to his lot, and devoted a great deal of care and attention to the work of the many committees and boards of which he was a member. He served on the Senate of the University, was dean of the Faculty of Engineering and chairman of the Board of Studies in Electrical Engineering.

In 1942 Prof. Fortescue was elected president of the Institution of Electrical Engineers, which was a fitting recognition not only of his professional standing and academic qualifications but also of the devoted work he had done for the Institution for very many years.

Prof. Fortescue very rarely took any rest from his work, and since his retirement in 1946 he had been active in the service of the University and also at Southampton Technical College in connexion with the development of courses in telecommunications, electronics and electrical measurements. He is survived by his wife, son and daughter.

A. Rushton

We regret to announce the following deaths:

Sir Robert Pickard, F.R.S., formerly director of research, British Cotton Industry Research Association, on October 18, aged seventy-six.

Prof. Ida Ward, C.B.E., emeritus professor of West African languages in the University of London, on October 10, aged sixty-nine.

NEWS and VIEWS

The Nobel Prize for Peace (1949): Lord Boyd-Orr, F.R.S.

The Nobel Prize for Peace (1949) has been awarded to the Right Hon. Lord Boyd-Orr. Lord Boyd-Orr's scientific life can be divided into certain fairly well-defined phases. There is first the period of finishing off the work which he began in the Institute of Physiology of the University of Glasgow. His most important contribution at that time was made in collaboration with Prof. E. P. Cathcart and was concerned with the "Energy Expenditure of the Infantry Recruit in Training"; then he commenced the study of the mineral requirements of farm animals along with Walter Elliot, Arthur Crichton and others. This culminated in the production of a stimulating book entitled "Minerals in Pastures and their Relation to Animal Nutrition"—a book which set the Empire thinking and working on its pasture problems. About 1924 Boyd-Orr began to apply his knowledge of mineral nutrition in farm animals to allied problems in children and native populations, and in 1930 along with Miss Clark he published a dietary survey of 607 families in seven cities and towns in Scotland. A little later the problem of nutrition in relation to susceptibility to disease exercised his mind, and his work in this and other spheres was recognized by his admission to the fellowship of the Royal Society in 1932. Three years later he was created a Knight Bachelor.

In 1936 Boyd-Orr published his epoch-making survey of adequacy of diet in relation to income:

"Food, Health and Income". This bore witness to the fact that his interests had widened and now embraced the economic and social aspects of food production and human health. In the years immediately preceding the Second World War, Boyd-Orr had set in motion a large-scale dietary survey of human populations, the finds of which proved of considerable value to the Scientific Food Policy Committee of the War Cabinet in formulating its nutritional policy. During 1942–45 Boyd-Orr filled the dual role of director of the Rowett Research Institute and professor of agriculture in the University of Aberdeen. Then in 1946 there followed his appointment as director-general of the United Nations Food and Agriculture Organisation, after which academic honours have been showered upon him. He was for a time Member of Parliament representing the Scottish Universities; in 1945 he was made rector and a year later chancellor of the University of Glasgow. In September of this year he was re-elected president of the World Movement for World Federal Government. Now the award of the Nobel Prize for Peace has set the seal to his work for world peace.

School of Pharmacy: University of London

THE Pharmaceutical Society of Great Britain established its School of Pharmacy in Bloomsbury Square in 1842; this School has played an important part in the training of pharmacists and in the advancement of pharmaceutical knowledge. In 1925 it was admitted as a School of the University of London, and the scope and prestige of its research work were increased by the opening of the Pharmacological Laboratories under the direction of Prof. J. H. Burn. In 1933 the school became the "College of the Pharmaceutical Society". The original building had by this time become hopelessly inadequate, and plans were made to provide fine accommodation for the College in the new building in Brunswick Square, which was also to serve as the headquarters of the Society. These plans were interrupted in 1939 before the building was complete, and when the War ended it was impossible to proceed with them. The solution of the problem thus presented has now been found. The College of the Pharmaceutical Society is born again as an independent School of Pharmacy in the University of London. The University has purchased the unfinished building and intends to give the School the same space it would have received from the Society. The first session of the new School, which is also the hundred and seventh session of the old School, opened on October 5. In the inaugural address Prof. G. B. Jeffery gave an interesting review of the history of the Society and the University, and held out high hopes for their joint future. Those who are responsible for this development are to be warmly congratulated. The old over-crowded building is still in use; but there seems to be a prospect of better things to come.

Memorial to James Nasmyth

A BRONZE plaque has recently been placed on 47 York Place, Edinburgh, to mark the birthplace of James Nasmyth, the celebrated inventor, engineer and astronomer, who was born there on August 19, 1808. The tenth of the eleven children of the distinguished painter, Alexander Nasmyth (1758–1840), he inherited from his father his artistic skill and mechanical ingenuity. He was brought up in surroundings which stimulated his natural talents, and at the age of twenty-one he became the assistant of the famous Henry Maudslay, of Lambeth, being thereby brought into contact with many able engineers. When twenty-six, he started in business for himself in Manchester, and two years later founded the Bridgewater Foundry, Patricroft, for the manufacture of locomotives, machine tools, etc., which soon gained a European reputation. By the time he reached the age of forty-eight, Nasmyth was able to retire with an ample fortune, and settling at Penshurst, Kent, he erected an observatory and became well known for his observations and theories of the sun and the moon. Among his many mechanical inventions the most important was the steam hammer; but it can be said that he made improvements in all machines which occupied his attention. His "Autobiography", edited by Samuel Smiles and published in 1883, is among the best of such works written by engineers. Nasmyth died in London on May 7, 1890. The new memorial at Edinburgh has been erected through the efforts of the Royal Scottish Society of Arts, the Institution of Mechanical Engineers, the Royal Scottish Academy, the Royal Society of Edinburgh and the Watt Club.

List of Reference Books

THE National Book League has recently issued a selected list of reference books intended for the general reader which has been compiled by W. A. Mumford, borough librarian of Cambridge, with the assistance of the borough librarians of Finchley, Folkestone and Hornsey (pp. 32. London: Cambridge University Press, 1949; 1*s.* net). Although it omits very technical and specialized works and contains only eleven entries under "Science and Technology", some of which could be challenged, it should prove a useful desk tool to those in charge of works or small technical libraries who do not find A. D. Roberts's book essential. In arrangement the list follows generally the Dewey classification.

Spawning Act of the Bitterling

AMONG a number of interesting contributions to the silver jubilee number of *The Aquarist and Pondkeeper* (May 1949), a paper on the breeding habits of the bitterling (*Rhodeus amarus*) is noteworthy. The author, the well-known fish photographer, W. S. Pitt, brings together a number of contradictory accounts of the manner in which the female deposits her eggs in the freshwater mussel, where they afterwards undergo development. It is generally believed that the long ovipositor is inserted into the mussel; but his own observations, and those of his brother, suggest that this is not so. So far as they could see, the bitterling merely strikes the siphon of the mussel with the part of her body immediately in front of the ovipositor, the latter trailing loosely behind, being neither inserted into the mussel nor sucked in by it. The late J. R. Norman, in a letter to Pitt, described a wide-lipped tube at the base of the long, narrow ovipositor and showed that it is possible for the egg to be shed through either tube. Some observers, including in recent years L. H. Bretschneider and J. J. D. de Witt, have insisted that the long ovipositor is inserted into the siphon and that through it the egg is passed. It appears that the act of deposition occurs so quickly that details are difficult to follow, and the act therefore seems to be a suitable subject for investigation with a cine-camera in the hands of an expert photographer and aquarist possessed of much patience. Perhaps Mr. Pitt himself will undertake the task.

Geoglossum Fungi of Japan

A VERY detailed account of "Geoglossaceæ Japoniæ" is given by Sanshi Imai in the *Journal of the Faculty of Agriculture, Hokkaido Imperial University* (45, Pt. 4, 155, 10 plates; October 1941). Thirty-seven species with three varieties and thirteen forms are described. About 24 per cent are endemic, 76 per cent are common with North America (among which 24 per cent are confined to the two regions) and 51 per cent are common with Europe. The author proposes three sub-families for the Japanese Geoglossaceæ—Geoglossoideæ, Cudonioideæ and Hemiglossoideæ—and all the species and forms are critically described.

Scientific Papers of the Middle East

A THIRD "List of Scientific Papers published in the Middle East", covering those received during August 1, 1948–March 15, 1949, by the Science Co-operation Office, Middle East, of the United Nations Educational, Scientific and Cultural Organisation, has recently been published (No. 3; pp. 58; Cairo, 1949). The list is classified by subjects according to the Universal Decimal Classification and is provided with an alphabetical list of periodicals and serials indexed, arranged by countries. Some brief notes on the activities of the Office are included. In style and production the present List is a great improvement on earlier lists and is well designed to further its purpose of facilitating the exchange of literature and of increasing the opportunities for scientific workers to benefit from the contributions of the Middle East to science.

South American Congress of Research Workers in Agronomy

APPROXIMATELY three hundred research workers are expected to participate in the first South American Congress of Research Workers in Agronomy, of whom some 220 will represent the Argentine, Brazil and Uruguay, and the remainder will come from the other South American countries and the United States. The Congress will be held during November 13–19, and the meeting place will be the Experiment Station of La Estanzuela in Uruguay, suitable alike for its relatively central position and for the signal services it has rendered to South American agricultural research. Five sections will discuss (1) climate and soil, or general ecological questions; (2) crops and herbage husbandry; (3) animal husbandry; (4) the industrialization of agricultural products; and (5) agriculture and the man, or rural sociology and economics, including marketing problems. Organisation is in the hands of a Uruguayan committee representing government and university authorities under the presidency of Dr. A. Boerger, director of La Estanzuela. The problems to be attacked are such as have no national frontiers but are confined solely by ecological limits.

University of Sheffield

THE following appointments have been recently made in the University of Sheffield: Dr. M. Holt and Dr. D. R. Davies to be lecturers in applied mathematics; J. Webster to be lecturer in botany; J. K. A. Beverley to be lecturer in bacteriology; J. W. Roe to be lecturer in industrial hygiene; Dr. J. C. Appleby to be bacteriologist in the Department of Medicine.

The Night Sky in November

FULL moon occurs on Nov. 5d. 21h. 09m., U.T., and new moon on Nov. 20d. 07h. 29m. The following conjunctions with the moon take place: Nov. 15d. 01h., Mars 1° S.; Nov. 15d. 14h., Saturn 0·8° S.; Nov. 23d. 19h., Venus 2° N.; Nov. 24d. 13h., Jupiter 5° N. In addition to these conjunctions with the moon, Mars is in conjunction with Saturn on Nov. 30d. 21h., Mars being 0·2° N. Mercury rises about 1¼ hr. before the sun on Nov. 1 and is visible in the eastern sky, but draws closer to the sun and is in superior conjunction on Nov. 21. Venus sets about two hours after the sun and is conspicuous in the western sky, stellar magnitude −4, the visible portion of the illuminated disk varying between 0·6 and 0·44. Mars rises soon after midnight throughout the month. Jupiter sets at 21h. 10m., 20h. 25m. and 19h. 40m. on Nov. 1, 15 and 30 respectively, but in the latitude of Greenwich does not rise more than 18° above the horizon. Saturn, in the constellation of Leo, rises at 2h., 1h. 10m. and 0h. 15m. at the beginning, middle and end of the month respectively. Occultations of stars brighter than magnitude 6 are as follows: Nov. 3d. 20h. 30·4 m., ζ Pisc. (*D*); Nov. 10d. 21h. 32·1m., 47 Gemi. (*R*). *D* and *R* refer to disappearance and reappearance respectively, and the latitude of Greenwich is assumed. The Leonid meteors are due during Nov. 14–19 and the Andromedids during Nov. 18–23, but these showers are now feeble and supply comparatively few meteors.

Announcements

MR. G. P. MEREDITH, lecturer in educational psychology in the University of Leeds, has been appointed professor of psychology.

DR. R. A. V. RAFF, a specialist in high-polymer research, has been appointed to a new fellowship on plastics established in the Mellon Institute by Koppers Company, Inc. Dr. Raff was previously for eight years employed by Howard Smith Paper Mills, Ltd., Cornwall, Ontario.

THE one hundred and twentieth course of Christmas Lectures at the Royal Institution "adapted to a Juvenile Auditory" will be delivered by Dr. P. Dunsheath on December 29, 31, January 3, 5, 7 and 10 at 3 p.m. He will speak on "The Electric Current".

UNDER the auspices of a group of ten organisations interested in the teaching of biology in schools, a joint conference on "The Living Body" will be held at University College, London, during December 2–3. The opening address will be given by Prof. F. R. Winton, who will speak on "Experimental Mammalian Physiology". Further information can be obtained from the Secretary, British Social Hygiene Council, Tavistock House North, Tavistock Square, London, W.C.1.

ERRATA. Communication on "Enzyme Activity and Nitrogen Content of *E. coli*" in *Nature* of October 8, p. 618: (*a*) The last sentence in the legend to the graph should read: $Z^{N^3}(N)$: acid formation in atmosphere of nitrogen from glucose expressed as ml. *N*/10 sodium hydroxide/hour/mgm. nitrogen. (*b*) p. 619, col. 2, line 11 from bottom, for "daughter bacterial cell on a . . ." read "daughter bacterial cell to a . . .". (*c*) p. 619, col. 2, line 10 from bottom, for "growth" read "formation or growth". (*d*) p. 619, col. 2, line 6 from bottom, for "Just after . . ." read "Just before or after . . .". (*e*) p. 620, line 5, omit word 'growing'.

RAMAN SPECTRUM OF ROCKSALT

By Dr. H. L. WELSH, Dr. M. F. CRAWFORD and W. J. STAPLE*
McLennan Laboratory, University of Toronto

THE Raman spectrum of rocksalt has been interpreted in two different ways: by Born and Bradburn[1,2] in terms of the Born theory of lattice dynamics, and by Krishnan[3] as evidence in favour of the Raman theory of crystal vibrations. The Born theory predicts the spectrum as a limited continuum with several maxima, formed by the superposition of various continuous but peaked distributions; the Raman theory requires essentially nine discrete lines which may be somewhat broadened by thermal motions. Confirmation of both interpretations has been claimed from the same experimental evidence, namely, spectrograms and microphotometer tracings published by Rasetti[4] and by Krishnan[3]. The inconclusiveness of the experimental results arises mainly from the lack of intensity measurements. The relationship of the peaks to the underlying continuum, which is the major point of contention, can be determined only by an *intensity* contour at high dispersion.

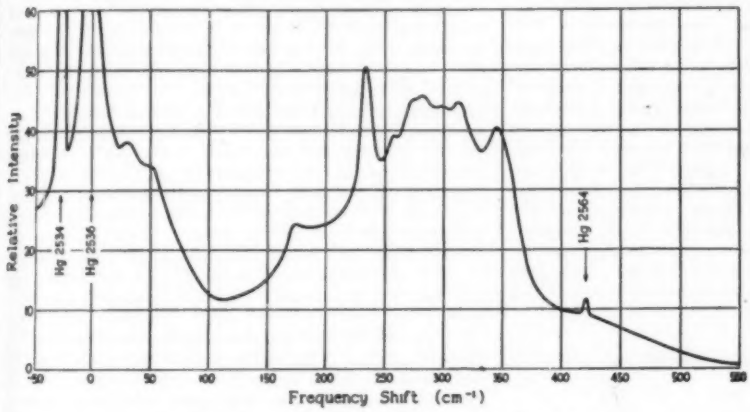

Fig. 1. Intensity distribution in the Raman spectrum of rocksalt

The curve of intensity distribution in the rocksalt spectrum (Fig. 1) was obtained with a two-prism quartz Littrow spectrograph giving at 2537 A. a linear dispersion of 0·037 mm. per wave-number, about three times that of the Hilger *E*.1 quartz spectrograph used by Krishnan in his later work. The polished rocksalt crystal, 2·0 cm. × 2·2 cm. × 18·5 cm., was contained in a quartz tube surrounded by a water-jacket to maintain a constant temperature. The effective scattering length of the crystal was doubled by placing an aluminium mirror in contact with the end of the crystal with glycerine. Properly placed diaphragms in front of the crystal prevented stray light from entering the spectrograph. Intense illumination was obtained from two spiral quartz mercury arcs with water-cooled mercury pools, operating on a current of 8 amp. The exciting line, 2537 A., was absorbed in the spectrograph by mercury vapour. Raman spectrograms with photographic densities suitable for accurate intensity work were obtained in exposures of forty-eight hours with a spectral slit-width of 3 cm.$^{-1}$. Ilford Special Lantern plates were used because of their relatively fine grain.

Each photographic plate was calibrated for intensity measurement by means of a stepped slit and the continuous spectrum of a low-voltage hydrogen arc, with an exposure time the same as for the Raman spectrum. The accuracy of the intensity work and the effect of parasitic radiation were checked by photographing the rotational Raman spectrum of nitrogen, for which the relative intensities of the lines can be calculated from theory. The exposure time was forty-eight hours and the experimental conditions similar to those for the rocksalt spectrum. A comparison of the observed and calculated intensities showed that the measurements, except at very low photographic densities, had a maximum error of 4 per cent at displacements greater than 30 cm.$^{-1}$ from the exciting line. Closer than 30 cm.$^{-1}$ to the exciting line the measurements were less accurate, but the background was still so low that the first rotational line at 12 cm.$^{-1}$ was distinguishable. A small error, varying approximately linearly with wave-length and due to the optical arrangement of the high-dispersion spectrograph, was detected in the nitrogen spectrograms and allowed for in the intensity measurements for rocksalt. The intensity contour for rocksalt given here is the average of four plates. When the values for the four plates were normalized to give the same integrated intensity, the intensities for any one plate did not depart by

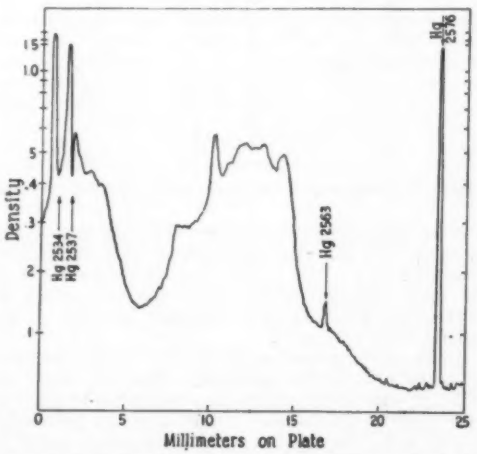

Fig. 2. Microphotometer tracing of the Raman spectrum of rocksalt

* Holder of a scholarship under the Ontario Research Council, 1947–48.

more than 4 per cent from the mean. Minor fluctuations due to graininess of the plate were smoothed out, but no feature of the spectrum which appeared in all four plates has been omitted in the average curve. The effect of graininess is small, as may be seen in the microphotometer tracing (Fig. 2).

The intensity distribution shows that the Raman spectrum of rocksalt consists of a continuum with superimposed maxima of small intensity relative to the continuum. The most prominent 'line' in the spectrum, at 234 cm.$^{-1}$, rises only about 50 per cent in intensity above the continuum. The observed half-width of this line is 8 cm.$^{-1}$, whereas the half-width of the mercury line at 2576 A. is less than 1 cm.$^{-1}$, when the correction, 3 cm.$^{-1}$, is made for the slit-width. The other maxima recorded rise above the continuum by amounts varying from 10 per cent to 1 per cent. It is therefore practically impossible to interpret the spectral distribution in terms of a limited number of discrete lines as required by the Raman theory. On the other hand, the intensity contour is, at least qualitatively, a striking confirmation of the Born theory. The positions of the maxima are also in good agreement with the calculations of Born and Bradburn. This is shown in the accompanying table, where the calculated maxima in the more intense frequency branches have been related to the peaks found experimentally. The designation of the frequency branches is that used by Born and Bradburn. Of especial interest are the broad maximum at 415 cm.$^{-1}$ near the calculated position for $2\omega_1$, and the two low-frequency maxima at 34 and 53 cm.$^{-1}$, corresponding to the two groups of difference tones. It should also be noted that the internal consistency in the assignment of the frequencies is improved when the frequencies in the pairs ω_2, ω_4 and ω_5, ω_6 are taken as not quite equal to one another. These inequalities are in accordance with the calculation of the rocksalt frequencies by Kellermann[5], but are neglected in the simplified treatment of the Raman spectrum by Born and Bradburn.

Observed maxima (cm.$^{-1}$)	Branch	Calculated maxima[1] (cm.$^{-1}$)
415 (broad)	$2\omega_1$	428
346 (broad)	$\omega_1 + \omega_2$, $\omega_1 + \omega_4$	373
314	* $2\omega_2$	317
299	$2\omega_2$	
285	$\omega_2 + \omega_3$	296
275	$2\omega_4$	
256	$\omega_2 + \omega_5$	259
234	$\omega_2 + \omega_6$	
174 (broad)	$2\omega_5$, $\omega_3 + \omega_6$, $2\omega_6$	198
55	$\omega_1 - \omega_2$, $\omega_1 - \omega_4$	78
	$\omega_2 - \omega_3$, $\omega_3 - \omega_4$	76
31	$\omega_2 - \omega_5$, $\omega_5 - \omega_6$	16

Observed and calculated maxima in the Raman spectrum of rocksalt.

The shifts found by us for the nine higher frequencies are in good agreement with Krishnan's measurements. However, there is no evidence on our spectrograms for the other ten frequencies reported by Krishnan and assigned by him to the second-order spectrum.

Born and Bradburn have already shown that there is good qualitative agreement between their calculated intensities and the microphotometer tracings of Rasetti and Krishnan. No attempt has been made to fit their calculations to our intensity curve by an adjustment of the coupling constants, since a good quantitative agreement would probably be found only with a more complete calculation of both the frequency distributions and the Raman intensities.

We are indebted to Prof. E. C. Bullard for directing our attention to this problem.

[1] Born, M., and Bradburn, M., *Nature*, **156**, 567 (1945); *Proc. Roy. Soc.*, A, **188**, 161 (1947).
[2] Born, M., *Nature*, **157**, 810 (1946); **159**, 266 (1947).
[3] Krishnan, R. S., *Nature*, **156**, 267 (1945); **157**, 623 (1946); **159**, 266 (1947); *Proc. Ind. Acad. Sci.*, A, **26**, 419 (1947).
[4] Rasetti, F., *Nature*, **127**, 626 (1931).
[5] Kellermann, E. W., *Phil. Trans. Roy. Soc.*, A, **238**, 513 (1940).

MUSEUM OF THE HISTORY OF SCIENCE, OXFORD

NEARLY twenty-five years ago the Lewis Evans Collection of historic scientific instruments was opened at Oxford by the Earl of Crawford and Balcarres, president of the Society of Antiquaries. The collection consisted chiefly of astrolabes, dials and mathematical instruments, and was at once augmented by the transfer of many interesting pieces of 'philosophical apparatus' from many of the Oxford colleges. Dr. R. T. Gunther, the curator, was most assiduous and persuasive in acquiring interesting exhibits, and it was not long before the collection had outgrown the Museum Ashmoleanum in which it had so suitably been placed. In 1935 the Lewis Evans Collection became the Museum of the History of Science, and the need for further space was met by the promise that the whole of the Old Ashmolean Building would be transferred to the Museum in 1942, thus trebling the space available. Unfortunately, Dr. Gunther did not live to see this promise fulfilled, for he died in March 1940, leaving the Museum and his fourteen volumes of "Early Science in Oxford" as a lasting memorial to his labours for the history of science. The War delayed the occupation of the Museum's new galleries; and even after the Ministry of Labour had vacated the building, it was necessary to instal a new system of lighting and heating. Thus it was not until October 11 of the present year that the collections were permanently arranged and, by a happy concurrence, opened by the present Earl of Crawford and Balcarres, chairman of the National Art Collections Fund.

The ceremony was held in the Divinity School. The curator, Dr. F. Sherwood Taylor, outlined the past history and future plans of the Museum, very much as they are here described. The vice-chancellor of the University, the Very Rev. Dr. John Lowe, then welcomed the Earl of Crawford and Balcarres. He deplored the divorce between present practice and past history, which, he said, has nowhere been so complete as in the domain of science. He believed that in order to get a long-term view of what is being done, it is helpful to know how it all grew up, and declared that it is in accordance with the general traditions of the University that the long period of preparation and development which has led up to the modern practical pursuit of science should not be neglected, and that it has been the policy of the University to foster and increase so far as possible this interesting collection.

Lord Crawford said that the progress made since the first opening, twenty-five years before, was a memorable achievement. It marked another stage in the gradual re-opening of the museums of Great

Britain, which has proved to be a slow, painful and laborious process. Many of these still remain closed, and for ten years the public, and especially the younger generation, has been deprived of what they should enjoy—the greatest and oldest possessions of the country. He hoped that authority would remember that far greater progress has been made abroad. Returning to the subject of the Museum, he remarked on the beauty of the scientific instruments of the past, in which utility and beauty are happily married. The stream of tradition which made objects of use into objects of beauty also has never moved so sluggishly as to-day.

The company then proceeded to the Old Ashmolean Building, and Lord Crawford opened the door with the massive and beautiful key made for it in 1683.

The Museum is now laid out on three floors. The top one, the former Musæum Ashmoleanum, is devoted to the history of time-telling, and of physics other than optics. The ground floor, once the School of Natural History, contains optical instruments, most of which are derived from the collection of Dr. Regina'd Clay, acquired during the War, while others come from the Radcliffe Observatory or the Shepherd Collection of the Royal Astronomical Society. The basement, which from 1683 until 1857 contained the Chemical Laboratory, is appropriately given over to chemistry and medicine; the Daubeny collection of chemical apparatus, deposited by Magdalen College, is the principal exhibit. A guide to the collections in their new form is now available*.

The work is not yet completed. The removal of the brick piers and girders which disfigure the basement is projected, as is also the provision of adequate library and lecture-room furniture; and there is, of course, an unlimited prospect of research.

The functions of the Museum are fourfold: first, to collect and preserve; secondly, to investigate; thirdly, to display; fourthly, to instruct. Historic scientific instruments are fast disappearing: it is but rarely that we find such things as Lewis Evans collected. The first need, therefore, is to collect what remains and to preserve it from damage. On this depends all the other functions of the Museum. Future generations may well investigate more acutely, display more brilliantly, teach far better—but they will almost certainly be less well able to collect. Instruments find their way to collectors and thence to museums; they are destroyed by fires or acts of war; there can never be any more of them and their price continually rises.

Our second function is to investigate. The history of scientific instruments is largely unwritten, and our contribution will be the issue of a comprehensive catalogue with historical notes. The first part to be issued will be that dealing with the time-telling instruments of the Museum, notably the dials, quadrants and nocturnals.

Our third object—to display—is not always in accordance with the first. A thousand polishings of a brass instrument will remove most or all of the inscriptions upon it, and in such cases there is war between those who desire to display the full beauty of these objects and those who would preserve them. We have unreservedly sought to preserve, having our eyes fixed upon a future of incalculable extent. Here again there is room for research into the question of the air-conditioned museum-case in which deterioration should be arrested.

* A Brief Guide to the Collections of the Museum of the History of Science. Pp. 59. (Oxford, 1949.) 2s. 6d.

The fourth purpose of the collections is instruction. Here again there is a conflict. Are we, given forty square feet of case for astrolabes, to show but a tenth of those we possess and fill the rest of the space with explanatory matter designed to instruct the student in the nature and use of that instrument? We have supposed that this, a specialist museum, is primarily a means of research rather than of instruction, and that our first need is to show everything that is of first-rate importance, and is not duplicated.

The Museum of the History of Science is not only a museum, for it is at present the centre of the teaching of the history of science at Oxford. Before 1939, Dr. Gunther had given a series of lectures on Oxford men of science to a number of the Colleges, but did not give any formal university lectures. During the War, courses in the history of science were provided for cadets; following upon this, the Curator and Dr. S. F. Mason and others have been giving formal courses of lectures on subjects connected with the history of science. At present these studies play but a very small part in the intellectual life of the University of Oxford; but when they come, as they must, to be recognized as of the first importance, the Museum of the History of Science will afford a rich source of material alike for the man of science, the historian and the philosopher.

F. Sherwood Taylor

PREHISTORIC AFRICA

SEVERAL new contributions to our knowledge of South African prehistory are to hand. Volume 4, Bulletin No. 13 of the South African Archæological Society contains a number of interesting articles. The Abbé Breuil describes some newly discovered rock-shelter paintings near Ladybrand, the technique of which is reminiscent of the Franco-Cantabrian art. Is it going to be found that prior to the already well-known rock-shelter paintings in the sub-continent there existed there an earlier, more naturalistic art? Breuil also discusses the age of the painted rocks and their authors. The last word has not been said on this subject.

Dr. C. van Riet Lowe contributes an account of some paintings recently found near Cathedral Peak in the Drakensberg, Natal. Judging by the few illustrations given, these would not appear to belong to an early series. Dr. B. D. Malan adds a short note on the Magosian at Howieson's Poort. The Magosian culture was first described by the present writer some years ago, the finds having been made by E. J. Wayland, then Government geologist in Uganda, at an ancient waterhole at Magosi in that country. Typologically the Magosian industry comprises very late Middle Stone Age elements with early Wilton additions. Indeed, one was tempted to see in it the birth of the Wilton culture out of a final Middle Stone Age cradle. The name, at any rate, has been accepted, and the existence of the Magosian culture is affirmed from British Somaliland to the Cape. The original collection from Magosi which was figured in the first description is housed in the Museum of Archæology and Ethnology at Cambridge. One can only hope that all the many Magosian discoveries in Africa are really Magosian. Frankly, I wonder whether the Howieson's Poort finds are quite the same thing, although I admit there are some similarities. Maybe, since I was there, other finds

have been made which confirm the similarity. There is a danger in over-simplification; a culture name can easily become a sort of dustbin into which many different discoveries are thrown.

Dr. van Riet Lowe has also contributed a short article in Portuguese for the Sociedade de Estudos da Colonia de Moçambique (Boletim Nos. 57–58; April–September 1948). Anything that can be done in the way of creating interest in archæological matters in this part of Africa is to be welcomed. Dr. van Riet Lowe has also given a useful summary (*British Science News*, **2**, No. 16) of the archæology of some of Dr. Robert Broom's famous sites in the Transvaal. Finally, in Volume 3, Bulletin No. 12 of the South African Archæological Society, Cape Town, Dr. B. D. Malan describes a new Middle Stone Age site near Utrecht, Natal.

M. C. BURKITT

RADAR RESEARCH AND DEVELOPMENT ESTABLISHMENT, MALVERN

THE Radar Research and Development Establishment of the Ministry of Supply held a series of open days at Malvern during the period September 21–23, thus giving the public its first chance of seeing the work of this well-known Establishment.

The Radar Research and Development Establishment is responsible for the research and development aspects of army radar equipment, both for the direction of anti-aircraft, coast and field artillery, and for the location of shipping, land vehicles and missiles. Although its history can be traced back to the Searchlight Experimental Establishment formed in 1917, the radar work which now absorbs the whole of the effort of the Establishment originated in a small research group detached to work at the Air Ministry Bawdsey Research Station in 1936 under the direction of Mr. (now Sir Robert) Watson-Watt. Whereas the Bawdsey Research Station was primarily concerned with radar for the Royal Air Force and later became the Telecommunications Research Establishment, the group concerned with developing radar to meet the army requirements broke away in 1939 to rejoin the parent Establishment and to form what might be termed the nucleus of the present Radar Research and Development Establishment at Christchurch in Hampshire. The Establishment moved to Malvern in 1942. Among a number of men of science who have directed its work since its inception, one finds Dr. J. D. (now Sir John) Cockcroft, who was chief superintendent during 1941–44. The present chief superintendent is Mr. P. E. Pollard, who was a member of the original research team under Sir Robert Watson-Watt in 1936.

The exhibition was opened on September 21 by the Minister of Supply, Mr. G. R. Strauss, and attendance on this day was limited to leading representatives of the fighting Services, the Civil Service, universities and industry, together with the Press. On September 22 the exhibition was attended by more than a thousand members of other government establishments, the universities and industry, while on the last day members of the general public were admitted. The impressive list of exhibits numbered more than a hundred, and a selection of the more interesting items is described below.

Anti-aircraft Gun-laying Radar. The purpose of the gun-laying radar is to provide accurate and continuous information of the position of an aeroplane or other target so that a 'predictor', or other computing equipment, can calculate where the gun should be pointed in order that the shell shall be effective against the target. There were eleven exhibits covering the work of the Establishment on gun-laying radar, including examples of the various types of set built dating from the 6½-metre wave-length, range and bearing only, set of 1939 to the modern 10-cm. wave-length 'auto-follow' system. In this modern set a paraboloid of about 5 ft. aperture forms the aerial system. In place of the normal hand turning, the aerial is automatically driven by servo-motors controlled by the radar pulses reflected back from the target in such a way that it continues to point at the moving target. The result is that the position of the target is accurately indicated and followed, however it may 'jink' or turn, without the aid of a human operator. An impressive exhibit showed this 'automatic-follow' radar coupled up through a predictor to a battery of four heavy anti-aircraft guns which fired demonstration rounds at a passing high-speed aircraft. The whole operation, apart from the actual loading of the guns, appeared to be completely automatic.

Field-artillery and Coast-artillery Radar. Field-artillery radars are required to detect enemy vehicles, to locate enemy mortar positions from observations of mortar trajectories, and to assess the accuracy of gunfire by observation of point of impact of shells. Similarly, coastal-artillery radars are required to detect enemy ships and to direct the fire of coastal batteries.

The 3-cm. wave-length coastal-artillery radar exhibited has a rather unusual display in that in addition to the normal sector-scanned plan-position-indicator display, facilities are provided for 'strobing' out a portion of the sector in both range and bearing, enabling an enlarged picture to be displayed on a second cathode ray tube. The result is that when the set is used for directing artillery fire against shipping, one is able to get a plan view of the ship on the magnified display. In addition, the resolution of the set is so good that the shell splashes are also clearly indicated, enabling small corrections to be applied to the direction of fire until a shell is actually seen to fall on the ship.

Radar for Ballistic Measurements. Ten exhibits were devoted to showing the application of radar to the determination of speed, spin and direction of experimental rockets and other projectiles. Velocity and spin measurements are normally made by observation of the Doppler frequencies produced by the recession of the target on a continuous wave (as opposed to the normal pulse) radar. An interesting exhibit in this group showed a tiny rocket-propelled missile which was followed on a 3-cm. wave-length continuous-wave radar during its flight. The Doppler frequency produced by beating the outgoing and returning radio signals could be heard on a loud-speaker and was fed to a frequency-measuring meter which indicated the speed of the missile in miles per hour.

Radar Aerial Research. Of the research items shown, some of the most interesting were due to the group working on aerials. In addition to simple demonstrations showing the focusing properties of the usual dipole arrangements, Yagi and paraboloid aerials, a considerable amount of new work on metal

plate, rod, delay and variable refractive index lenses was shown. One exhibit showed a large metal-plate lens of 8 ft. aperture and focal length 11 ft. 8 in. operating on a wave-length of 10·7 cm. The horn feed for this lens was traversed to and fro across the focal plane, and monitor receiver aerials indicated that the beam scanned over ± 18° with a loss of less than 2 decibels at the extremities of the scan. A further exhibit in this section showed apparatus for the automatic recording of phase and amplitude distribution in the wave-front across the aperture plane of experimental lenses.

General Research Items. A number of research items, the results of which aim at producing radar sets giving better performance, was shown. These items covered a wide field and included work on the magnetic clutch principle initiated at the National Bureau of Standards in the United States. The clutch relies for its action on the fact that a 'sludge' of fairly low viscosity, produced by immersing iron filings in oil, solidifies when subjected to a magnetic field. This work aims at producing improved servo-motor drives. Another interesting exhibit demonstrated the production of a standard milliwatt of power on a wave-length of 10 cm. for the calibration of radar receivers, while new techniques and developments in radar test gear and electro-chemistry were also shown.

Workshop Exhibits. Essential to the success of modern research workers is the co-operation of first-class workshops. The dozen or so exhibits in the workshops of the Establishment indicated just how well its scientific workers are served in this respect. A fine collection of modern machine tools was shown with examples of turning, milling, grinding, moulding and plating. Examples of completed work included a large centrifuge capable of subjecting weights of 150 lb. to 200 *g*.

A film entitled "Debellamus Superbos", describing the work of the Establishment from the earliest sound-locating equipment to the present-day radar, was shown each day during the exhibition.

F. E. Jones

ASSOCIATION OF SPECIAL LIBRARIES AND INFORMATION BUREAUX

ANNUAL CONFERENCE

THE twenty-fourth annual conference of the Association of Special Libraries and Information Bureaux, the first to be held since the amalgamation of the Association with the British Society for International Bibliography, presented comparatively few features of interest to scientific workers generally. Although rather more than two hundred were present at Ashorne Hill, Leamington Spa, during the week-end September 9–12, and the attendance represented a wide range of interests, the Conference in some ways did not quite provide the opportunity for discussion of the Association's own affairs that was usually given by the annual general meeting, nor was the gap filled by Dr. Percy Dunsheath's reference to the early history of the Association at the outset of his presidential address on the Saturday morning.

The main features of Dr. Dunsheath's address were his references to the inadequacy of present-day facilities for reference libraries in science and technology and to the need for establishing higher standards of training and qualification for the staffs employed in scientific and technological libraries. Both these matters, he considered, call for strong action, and he maintained that the present reference library facilities in science and technology are a disgrace to Great Britain. An intensively industrialized country like Britain is particularly dependent on the ready dissemination of existing knowledge among scientific men and technologists; yet stocks of books are not readily available on account of lack of space, grants for new books are falling more and more into arrears and the flood of new knowledge is increasingly beyond the capacity of the under-paid, under-staffed and under-equipped librarian. Dr. Dunsheath said that the Patent Office Library is the most useful technical library in London and the best for its purpose in the United Kingdom, but he complained that it is now closed at 6 p.m. instead of at 10 p.m., while delays in binding, the absence of books from open shelves and the inadequacy of staff—mainly due to a cut in the budget—seriously hinder its usefulness. Much the same criticism could be made of the Science Museum Library at South Kensington, and Dr. Dunsheath urged that provision of a new Library of Science and Technology in the centre of London, conceived on a grand scale, and using the practical experience and tradition of the Patent Office Library, would be the best contribution which the Government could make to our prosperity at the present time.

Following Dr. Dunsheath's address at a session on business archives, papers were given by Mr. F. G. Emmison, county archivist, Essex Record Office, and Mr. E. C. Baker, librarian and archivist of the Post Office, which were designed to assist members in selecting papers for retention, and which also discussed such archives as sources of history of business or industrial enterprises. Three papers presented at the afternoon session, which described the starting and operation of three new libraries, should be of particular interest to those who may be concerned with the formation and management of new research libraries or information centres. In one of those the library of the Institute of the Motor Industry was described by its librarian, Mr. C. E. C. Hewetson. Miss M. Gossett described the formation and operation of the library of the Atomic Energy Research Establishment at Harwell, and Mr. E. Ower, intelligence officer to the British Shipbuilding Research Association, the library of that Association.

The third session of the Conference, on Sunday morning, was concerned with the extraction of commercial and technical information from correspondence files, and the two papers presented by Mr. D. V. Arnold and Miss E. W. Parker considered both the most suitable techniques and the problem of ultimate storage. The fourth session, on Sunday afternoon, discussed the problems of obtaining official publications of interest, but centred essentially around those issued by H.M. Stationery Office, the director of which, Mr. W. Cox, contributed one of the three papers. The contents and arrangement of the daily, monthly and annual lists or catalogues issued by H.M. Stationery Office received some comment, while Miss Barbara Kyle dealt with problems presented by the United Nations Organisation's documents.

OCEAN SURFACE WAVES

ALL through the nineteenth century and well into the twentieth, mathematicians studied the problems suggested by the generation and propagation of waves on the surface of the sea and other bodies of water. But during all this time there was very little scientific observation of waves, and practically none of it was by means of specially designed measuring instruments. Oceanographers paid very little attention to the details of the phenomena.

But during the Second World War, it was part of the preparation for the landing of troops and material on beaches that forecasts should be made of the state of swell and surf on those beaches at particular times. This led to a mass attack by American and British workers on the problems involved, mainly by the study of observations; and the work has been continued since the War. A pamphlet has recently been published* which is the result of a conference held by the Section of Oceanography and Meteorology of the New York Academy of Sciences in March 1948, and many of the contributors have taken part in the war-effort. The pamphlet contains fifteen papers, and in six of these it is stated that the work was carried out for the United States Navy. It is edited by B. Haurwitz.

Three papers are mainly historical. C. C. Bates, of the United States Navy, gives an account of the utilization of wave forecasting in the invasions of Normandy, Burma and Japan. Excluding cases in which forecasts of winds were in error, it was found that forecasts of waves on the Normandy landing beaches were correct for 88 per cent of the time. J. D. Isaacs and T. Saville, jun., of the University of California, give a comparison between forecast and recorded waves on the Pacific coast. G. E. R. Deacon, of the British Admiralty Research Laboratory, describes studies of waves and swell carried out by his staff, much of which is post-war.

Three papers are mainly observational, or consist of the study of observations in the light of previously established theory. W. H. Munk, of the Scripps Institution, in the longest paper of the pamphlet, gives a study of the theory of the solitary wave and its application to surf-problems. H. R. Seiwell, of the Woods Hole Institution, gives a study of sea-surface roughness measurements in theory and practice. C. L. Pekeris reports on his work at Columbia University on the determination of the depth of an under-water explosion from measurements of the dome of spray.

Six papers are mainly theoretical. J. J. Stoker, jun., of New York University, writes on the breaking of waves in shallow water. There is an analogy between the theory of long waves in shallow water and that of the compressional flow in a gas. Stoker's paper interprets certain well-known results in gas dynamics in terms of water-wave phenomena. A. J. Abdullah, of the Massachusetts Institute of Technology, discusses wave-motion at the surface of a current which has an exponential distribution of velocity; and P. D. Thompson, of the Princeton Institute for Advanced Study, writes on the propagation of small surface-disturbances through rotational flow. These two papers extend the mathematical work of Lord Rayleigh and Sir G. I. Taylor. R. S. Arthur, of the Scripps Institution, describes an investigation of the effects of variability in direction of wind travel. J. B. Keller and F. John, both of New York University, write mathematical papers, the first on the solitary wave and periodic waves in shallow water, and the second on the action of floating bodies on ocean waves.

Details of a shore-based wave recorder and of a wave analyser are given by A. A. Klebba, of Woods Hole Institution, and M. Ewing and F. Press, of Columbia University, write a critical paper on several points in the study of surface-waves. M. A. Mason, of the U.S. Army Beach Erosion Board, describes the engineering applications of ocean-wave research.

The pamphlet shows the great progress which has been made in the subject during the past seven years.

J. PROUDMAN

* Ocean Surface Waves. *Ann. New York Acad. Sci.*, **51**, Art. 3, 343–572 (1949). 3 dollars.

INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS

GENERAL ASSEMBLY AT COPENHAGEN

THE fifth general assembly of the International Council of Scientific Unions was held in Copenhagen during September 14–16 by invitation of the Royal Danish Academy. Prof. Niels Bohr, president of the Academy, welcomed the delegates, stressing the importance of international science as a factor towards the maintenance of peace between the nations and also the need that we should adjust ourselves to our newly increased control over the resources of Nature. Prof. E. Borel presided in the unavoidable absence of the president of the Council, Dr. John A. Fleming.

The chief task before the meeting was a revision of the statutes of the Council which had been drawn up in 1931. One or two points may be noted. It was decided to divide Unions into two classes: General (Astronomy, Geodesy and Geophysics, Chemistry, Physics and Biological Sciences) and Specialized (Radio-Sciences, Geography, Crystallography, Mechanics and History of Sciences). No new international unions were admitted at this meeting, but the bureau was instructed to appoint a policy committee to report to the next general assembly on the principles which should govern the admission of new unions. It was agreed to arrange for joint commissions with the newly formed International Councils of Philosophy and Humanistic Studies and of Co-ordination of Medical Congresses; further, it was agreed to make contacts with regional bodies holding similar aims to those of the Council, such as the Pacific Science Congress and various pan-American scientific organisations.

New joint commissions between the Unions were formed on radiobiology and physics abstracting. The latter will co-operate with the physics abstracting body set up by the United Nations Educational, Scientific and Cultural Organisation, and will place the user's point of view before that body. The next meeting, on the invitation of the Royal Academy of Sciences of Amsterdam, was arranged to take place in the Netherlands in 1952. The Bureau of the Council for the next three years was elected as follows: *President*, Prof. A. von Muralt (Switzerland); *Vice-Presidents*, Prof. E. Borel (France), Prof. H. Solberg (Norway); *Members*, Dr. J. N. Mukherjee (India), Colonel E. Herbays (Belgium); *Past President*, Dr. John A. Fleming (United States); *General Secretary*, Prof. F. J. M. Stratton (Great Britain).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

The Structure Responsible for Action Potential Spikes in the Cat's Retina

It is well known from the work of Granit[1] that isolated action potential spikes may be recorded from the eyes of many animals by placing a micro-electrode in contact with suitable spots on the retina through the opened bulb. The cat is particularly suitable. The importance of this work makes it especially desirable to define as precisely as possible the actual retinal structures responsible for the spikes recorded, for such questions as the following come to mind in attempting to interpret and evaluate the full significance of Granit's results. How is it possible to get such good insulation in a packed structure like the retina using a 25-μ electrode? Why are large isolated spikes only found in some spots and not elsewhere? Is it because some typical structure happens to be exceptionally favourably placed for recording, or is the structure a comparatively rare one? Or are the spikes due to the synchronous firing of a patch of retinal cells, and if so, is this normal or pathological?

The work here described, carried out at the Nobel Institute for Neurophysiology, Stockholm, answers these questions and identifies the structure responsible for the spike; for example, the two spikes recorded in Fig. 2 were produced by a pair of ganglion cells shown in Fig. 3.

Experiment 1. When a micro-electrode is in position to record a large spike, it may often be moved 0·1 mm. or more without 'losing' the spike. Is the spread of the action potential as extensive as this, or does the micro-electrode get stuck in the vitreous and carry the retina along with it (for the opened bulb is flaccid)? A cluster of seven micro-electrodes was obtained by making a 'rope' of seven fine insulated silver wires, varnishing them into a rod, and cutting cleanly across. The distance between the centres of adjacent wires was 80 μ. Each wire could separately be connected to the amplifier by a multipolar switch.

When the middle electrode was adjusted to record optimally a large spike, each other electrode recorded the same spike at not less than half the amplitude. It follows that the spike may extend for not less than 0·1 mm. in all directions from the optimal point.

Experiment 2. Is this extensive action potential due to a single large cell or to a synchronous group of cells? The micro-electrode for this experiment was a very sharp needle, insulated except for the extreme tip. This was moved into the optimal position and then pressed upon the retina so that the responding structure was pricked and destroyed.

In some 60 per cent of records, the discharge frequency accelerated greatly and the spikes became small. Such results were rejected since they might

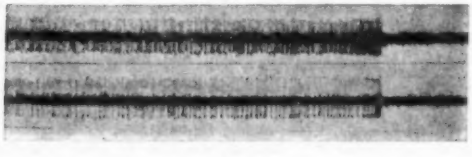

Fig. 1

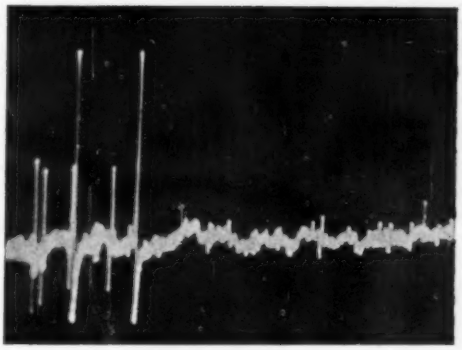

Fig. 2

be consistent with either hypothesis. The remaining 40 per cent showed a sudden and irreversible termination of the discharge (Fig. 1). There was never a record which showed a step down to half-size, etc. It follows that the spikes result from a single isolated cell the size of which is an appreciable fraction of 100 μ.

A modification of Palmgren's silver method[2] was developed, suitable for staining the ganglion layer of the whole (unsectioned) retina. It was found that giant ganglion cells 30–50 μ in size are scattered throughout the retina, sometimes in clusters, but often rather isolated. The size, nature and distribution of these cells seem precisely what we seek. No other appropriate structures were seen. Attempts to identify a given spike with a given cell were usually not very conclusive owing to the difficulty of adequate localization. The best confirmation I obtained is seen in Figs. 2 and 3.

Experiment 3. The vitreous was removed, the eye brightly lit and observed through a low-power microscope. The blood vessels are well seen against the green tapetum, and a map of them was traced by camera lucida. A micro-electrode explored this area, and, where isolated spikes were found, the position on the map was indicated by tracing the image of the micro-tip; an action potential record (Fig. 2)

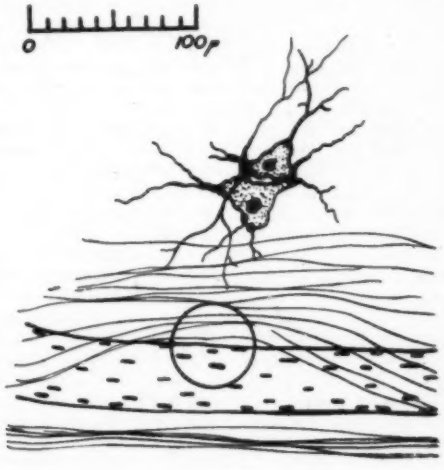

Fig. 3

was also obtained. Finally the retina was fixed, stained and mounted, and a second map of the blood vessels made. By comparing the two maps the electrode sites could be related to the retinal structure.

According to the map, one electrode site was at the circle marked in Fig. 3. The optic nerve fibres are seen dragged aside as the tip moved over the artery. Apart from the two cells shown, there was none within a radius of 500 μ from the circle except for one at the zero of the scale. The large and smaller cells of Fig. 3 appear to be correlated with the large and smaller spikes of Fig. 2, which were recorded from this locality.

Conclusions. The retinal spikes arise from large ganglion cells rather sparsely scattered in the ganglion layer of the retina (Fig. 3). The cell has a wide-thrown ramification of branching filaments extending some 0·5 mm. in all directions. These cells appear to collect impulses from a wide region of the retina, and to be ill-adapted to discriminate form and colour.

W. A. H. Rushton

Trinity College, Cambridge.
Sept. 13.

[1] Granit, R., "Sensory Mechanisms of the Retina" (Oxford Univ. Press, 1947).
[2] Palmgren, A., *Acta Zool.*, **29**, 378 (1948).

Role of Co-factors in the Inhibition of Bacterial Viruses by the Somatic Antigens of *Shigella sonnei*

During the course of an investigation[1] on the susceptibility of *Sh. sonnei* Phase I and II [2] and their phage-resistant variants to the *T* series of bacterial viruses, it was found that the Phase I micro-organism was lysed only by T_3 and T_6, whereas the Phase II bacillus was susceptible to T_3, T_4 and T_7 as well as T_2 and T_6. Solutions of the chemically purified and immunologically specific somatic antigens derived from Phase I and II bacilli[3] were incubated at 37° C. with approximately 2,000 particles per ml. of the appropriate viruses in an ammonium lactate medium (*F*)[4]. The bacteriophages employed were kindly supplied by Dr. Mark Adams, of New York University. Fresh stocks of the T_3 and T_7 viruses were prepared in nutrient broth using *E. coli* B as the host cell. T_2 and T_6 were prepared in *F* medium, and the T_4 virus in *F* medium containing 5 micrograms of l-tryptophane per ml. When 0·1 ml. of the mixture was assayed on nutrient agar by the Hershey poured-plate technique[5], there was no evidence that the lipocarbohydrate–protein antigens, even in concentrations as high as 0·1 mgm. per ml., would inhibit the lytic action of the viruses. This indicated that the purified antigens were incapable of preventing adsorption of the virus by the bacterial cell. These observations appear to be contrary to those of other investigators[6], who found that extracts of a variety of micro-organisms, which presumably contained immunologically active carbohydrates, have the power of preventing the adsorption of bacterial viruses to the host cell.

Further investigation has now revealed that the somatic antigen of Phase II *Sh. sonnei* in the presence of broth does inhibit the lytic action of T_3, T_4 and T_7 on the homologous micro-organism. On the other hand, the same antigen fails to inhibit the action of T_2 and T_6. It appeared that some constituent of the broth plays an essential part in the selective inhibition of T_3, T_4 and T_7 by the Phase II antigen. Anderson[7] has shown that l-tryptophane serves as a co-factor in promoting the absorption of T_4 and T_6 on *E. coli*. It seemed possible that this amino-acid might likewise be involved in the combination of T_3, T_4 and T_7 with the cell-free somatic antigen derived from *Sh. sonnei* Phase II.

Inhibition of bacterial viruses T_3, T_4 and T_7 by the somatic antigen of Phase II *Sh. sonnei*

Bacterial virus tested	Medium used	Final concentration of Phase II antigen in virus–antigen mixture*		
		0·1 mgm.	0·01 mgm.	0·001 mgm.
T_3	*F*	0	0	0
	Broth	99	65	12
	F plus 0·2 mgm. l-tryptophane per ml.	0	0	0
T_4	*F*	0	0	0
	Broth	99	96	93
	F plus 0·2 mgm. l-tryptophane per ml.	98	85	63
T_7	*F*	0	0	0
	Broth	98	93	81
	F plus 0·2 mgm. l-tryptophane per ml.	0	0	0

* The figures represent the percentage of virus inactivated. *F* = ammonium lactate medium.

When 0·2 mgm. of l-tryptophane per ml. was added to *F*, as little as 1 microgram per ml. of the Phase II antigen inhibited T_4, but had no effect upon T_3 and T_7, as can be seen from the accompanying table. Since the latter viruses are inhibited by comparable quantities of the Phase II antigen in the presence of broth, it would appear that in these instances still other co-factors are involved.

The antigen of Phase I *Sh. sonnei* caused no inhibition of T_2 and T_6 when tested with Phase I micro-organisms, or of T_3, T_4 and T_7 when tested with Phase II bacilli, even in the presence of broth. It is evident, therefore, that the inhibitory action of the Phase II antigen is highly specific, and that a co-factor is required in order for it to block combination of T_3, T_4 and T_7 with the host cell.

These experiments leave certain facts still unexplained. It is not yet known whether the virus combines with the protein, the lipid or the carbohydrate constituent of the somatic antigen; but work now in progress should establish this point. The nature of the co-factors present in broth which permits T_3 and T_7 to be inhibited by the antigen is not yet known. It would appear, however, that in the case of Phase II *Sh. sonnei* the substance which combines with T_3, T_4 or T_7 is a constituent of the lipocarbohydrate–protein complex distributed at the bacterial surface, and that this combination occurs only when an essential co-factor is present.

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Microbial Synthesis of Iodophile Polysaccharide by a *Clostridium* from the Cæcum of the Pig

Microscopic findings of Baker and his collaborators[1] have repeatedly confirmed the observation of Henneberg[2] that the microbial decomposition of carbohydrates in the gastro-intestinal tract may be accompanied by extensive synthesis of iodophile material within the bacterial cell. Where, as in the rumen microflora of the ox[3], biochemical observations have been attempted, they have shown that the iodophile material is a polysaccharide. A knowledge of the mechanism of such synthesis is essential, therefore, to a fuller understanding of the chemical changes accompanying the microbial breakdown of dietary carbohydrates, including starch and cellulose, in the rumen and cæcum of various animal species.

Although the taxonomic identity and growth requirements of many of the iodophile micro-organisms concerned are still unknown, in some instances they can be grown and identified in pure culture. Baker and Nasr[4], and Baker, Nasr and Morrice[5] have shown that an iodophile strain of *Clostridium butyricum* is primarily responsible for the breakdown of raw potato starch in the cæcum of the pig. The organism was isolated in pure culture on modified Beijerinck's medium[6]. Washed suspensions were then prepared according to the technique employed by Hehre and Hamilton[7] and Hehre[8] in the investigation of polysaccharide synthesis in *Neisseria pharyngitidis*, and buffered with sodium citrate. Preparations were made from young cultures, which showed little or no iodine reaction, as well as from older cultures in which the micro-organisms were replete with iodine-reacting material.

To suspensions of young cultures, glucose, glucose-1-phosphate and sucrose, respectively, were added in 2 per cent concentrations. Fructose and raffinose were also included in experiments made on older cultures. The suspensions with the various sugars added, together with control suspensions made up with buffer alone, were incubated at 37° C. A distinct, though faint, macroscopic iodine reaction was visible in the centrifuged deposit from the glucose-1-phosphate suspensions of young cells after 20 hr. After three days a strong reaction was obtained. The macroscopic findings were confirmed by microscopic examination of the micro-organisms, the contents of which were deeply stained. No reaction, macroscopic or microscopic, was observed in the control, glucose or sucrose suspensions. These observations indicated that a phosphorylating mechanism was involved in the endocellular synthesis of polysaccharide by young cells. In the older cultures the initial iodine reaction was retained in the control and glucose-1-phosphate, but disappeared in the glucose, sucrose, fructose and raffinose suspensions. The reason for the difference in behaviour between glucose-1-phosphate and the other sugars requires further investigation.

In conclusion, it may be recalled that Hehre[8] demonstrated that washed suspensions of *Neisseria pharyngitidis* synthesized iodophile polysaccharide directly from sucrose. The mechanism of synthesis, therefore, requires individual investigation for each of the isolable members of a mixed iodophile population. Thus the complex microbial facies of the gastro-intestinal tract of men and animals affords a rich province, as yet only incompletely explored, for the investigation of polysaccharide synthesis in a variety of bacteria, yeasts and protozoa.

Our thanks are due to Prof. F. G. Gregory, of the University of London, who suggested the experiment and supplied us with the glucose-1-phosphate necessary to carry it out.

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Participation of 'Brown Fat' Tissue in the Alarm Reaction

In the course of our studies on the general-adaptation syndrome, we were surprised to note the intense morphological changes which occur, during the alarm reaction stage, in the so-called 'brown fat'. It will be recalled that in various animal species, a special type of adipose tissue occurs, which, upon naked-eye inspection, is characterized by its brownish colour. Histologically, it resembles a lipid-storing endocrine gland (such as the adrenal cortex, the corpus luteum or the Leydig cells of the testis), because its epithelioid cells contain numerous small lipid granules and are richly supplied with capillaries.

Such 'brown fat' (synonyms: primitive fat organ, fat gland, hibernating gland, interscapular gland, lipoid gland, cholesterol gland, glandula insularis cervicalis, multilocular adipose tissue) is normally present throughout life in certain species, such as most rodents and hibernating animals. In other species, including man, it occurs quite regularly in certain locations (for example, the vicinity of the parathyroids, thymus and kidney) during embryonic life, but later tends to become completely transformed into common adipose tissue.

In hibernating animals, the chief function of the organ appears to be the storage of certain lipids during the active season, in order to make them available throughout the hibernating period. The purpose of 'brown fat' in non-hibernating animals is rather problematical. Cramer[1] postulated a close relationship between the lipid content of this tissue and that of the adrenal cortex, emphasizing that both these organs are extremely rich in cholesterol. Sweet and Hoskins[2] found that the 'brown fat' of the woodchuck contains as much testoid material (the equivalent of 100 γ of androsterone per 50 gm. of tissue) as bull testis, the richest natural source of testoids. Vignes[3] refuses to believe that the gland acts merely as a reserve of nutritive material, since in rats even mere extirpation of the interscapular accumulation of 'brown fat' causes emaciation and death.

An intense and rapid discharge of adrenal lipids is one of the salient manifestations of the alarm reaction[4], while fat from common adipose cells is much more slowly lost under the influence of non-specific systemic stress. We now find that the discharge of adrenal cortical lipids parallels the loss of sudanophilic material from the 'brown fat'.

In a preliminary experiment, twelve adult female piebald rats (average body-weight 120 gm.) were

divided into three groups of four animals each. The first group served as untreated controls, the second was exposed to cold, but allowed food, and the third was fasted during exposure to cold (0 to + 5° C. during 16 hr.). At autopsy the interscapular 'brown fat' of the untreated animals was yellowish-white and well developed, while that of the rats exposed to the stress of cold was partly involuted, brownish-red and extremely œdematous. Gastric ulcers, thymico-lymphatic involution and marked discharge of adrenal cortical lipids showed that this degree of cold produced a severe alarm reaction, especially in the fasted animals.

Upon histological examination of the 'brown fat', it was noted that the sudanophilic granules were almost completely discharged in the animals submitted to cold and fasting, but only partially discharged in those exposed to cold while taking food.

In a second series of experiments, twenty adult male piebald rats (average body-weight 130 gm.) were subdivided into four groups of five animals each. Group I acted as untreated controls; group II was exposed to cold (0 to +5° C.); in group III the spinal cord was trans-sized at the height of the seventh cervical vertebra, while the rats of group IV were repeatedly forced to exercise in a revolving cage until they collapsed from fatigue. Since recent experiments demonstrated that the phagocytic activity of reticulo-endothelial macrophages is greatly increased during the alarm reaction, we injected the animals of all four groups intravenously (one hour before they were to be killed) with 2 c.c. of a dilute solution of Higgins indian ink.

The rats were killed twenty-four hours after initiation of the experiment. At that time the interscapular 'brown fat' showed marked œdema, hyperæmia, discharge of sudanophilic lipids and increased phagocytosis of indian ink by the macrophages of this tissue. Simultaneously other manifestations of the alarm reaction were noted in all stressed groups, irrespective of the stimulus used.

It may be concluded that discharge of lipids from the brown fat represents a characteristic response during exposure to various types of systemic stress; it appears to be a sensitive early indicator of catabolism during the alarm reaction.

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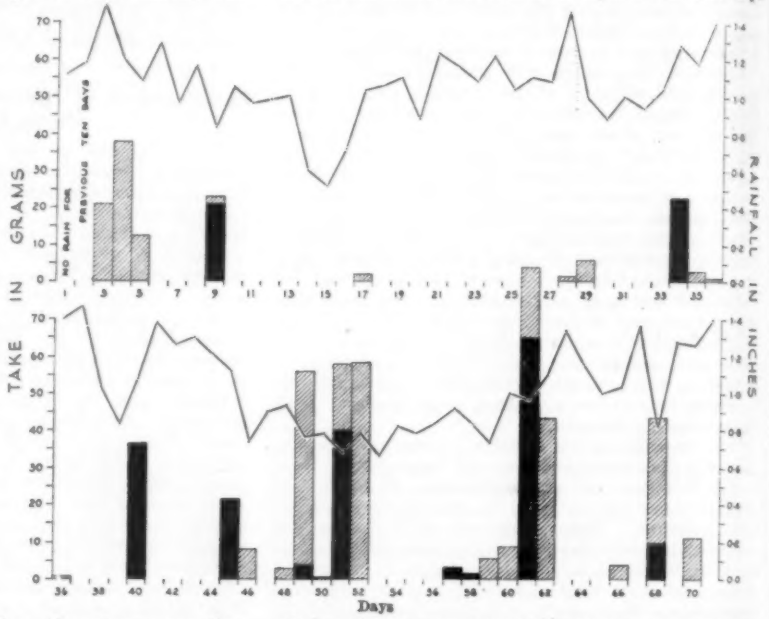
Effect of Rain on the Feeding of the Malaysian Rice-field Rat

Rattus rattus argentiventer, the Malaysian rice-field rat, is a common pest of standing crops and of waste-land covered by the tall grass 'lalang' (*Imperata cylindrica*). It is widely distributed throughout the Malaysian Islands, and in Malaya it is the most important host of the scrub typhus mite-vector *Trombicula akamushi* s.l.

During feeding tests on this rat, it was found that the amount of foodstuff taken from covered baiting points was related to the rainfall. In this part of Malaya rain falls intermittently in heavy showers, and it was found that rain after a period of some days



of drought was usually followed by a conspicuous increase in the food taken, while rain during the night tended to cause a decrease.

Tests were carried out in an area of lalang-covered wasteland. Dry rice was offered in covered boxes of a type which will be described elsewhere. Five baiting points were laid and weighed daily; but only the total take is recorded here. Rainfall was measured on a self-recording gauge. Rain charts and baits were changed daily at about 9 a.m., so the 'day' in the results quoted runs from 9 a.m. to 9 a.m.

The accompanying figure shows the bait-take and rainfall daily for 71 days. The rainfall blocks are shaded thinly for rain during daylight and solid for rain during the night.

It will be seen that on days 3, 9, 17, 28, 34, 40, 45, 57 and 66, each after three or more rainless days, an increase in take is shown on seven occasions and a decrease on two only. Such a result would be expected by chance about once in eleven trials. Further scrutiny, however, reveals that on days 9 and 45, when the take decreased, there was rain at night lasting on each occasion for some hours; whereas on days 34, 40 and 57, when rain fell at night also but the take increased, the shower lasted less than an hour on each occasion.

Change in the amount of rice eaten by the rat colony on nights during which rain fell (+, increase; −, decrease), compared with the duration and quantity of rain

Day number	Difference of take	Rain during the night	
		Duration	Quantity
50	+ 4 gm.	¼ hr.	0·01 in.
57	+ 1	¼	0·07
40	+ 12	¼	0·73
34	+ 1	¾	0·46
58	− 4	1	0·03
61	− 2	1¼	1·30
51	− 5	2	0·80
45	− 5	2¼	0·43
49	− 9	1¼*	0·08*
9	− 16	2¼	0·42
68	− 24	3	0·20

* This represents only the after-sunset fraction of a long heavy evening storm.

The effect of rain at night is made clear by the table, which shows the difference of take between the night of rain and the previous night, positive if an increase, negative if a decrease. It is evident that prolonged rain at night causes a reduction in the amount of food taken.

To sum up, therefore, this rat shows an increased feeding activity after rain, although rain at night reduces the amount of food taken, possibly by reducing the time available for feeding. The importance of this observation with reference to the ecology of the scrub typhus mite-vector becomes apparent when it is found that the larval mite is more active in its search for a host when the ground is damp with rain or dew. If, as seems likely, the increased feeding activity of the rat is a reflexion of an increase of general activity, the effect of rain after a short drought would be to increase the likelihood of the mite and its host meeting one another.

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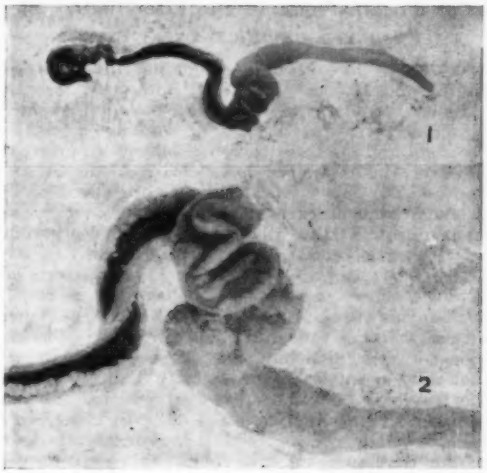
Occurrence of *Saccoglossus kowalevskyi* (?) on the North Kent Coast

On May 10 I was fortunate enough to find a large enteropneust on the flats at Whitstable which agrees well, except in size, with the descriptions of *Saccoglossus kowalevskyi* (A.Ag.) given by Spengel[1] and Van der Horst[2]. A few days later, R. P. Dales, of this Department, found a second but smaller specimen which was, however, incomplete. Both specimens were dug up from near the mean low-tide mark in a region where the sand overlying the clay contains a high proportion of shell debris.

The complete specimen was nearly twice as large as those the measurements of which are quoted by Spengel and by Van der Horst, for, although a portion was missing from the hinder end of the trunk, its total length during life was about 12 cm. as compared with 6–7 cm. cited in the literature. The proboscis during life varied in length from 1 to 2 cm., while the collar, almost as broad as it is long, measured about 0·4 cm. in length.

The two photographs, although not as clear as could be desired, show the important external features which distinguish *S. kowalevskyi* from related species. These features are: (1) the gonads, which begin almost immediately behind the collar and form projecting ridges along the dorsal surface of the trunk; (2) the ventral muscle bands, which are seen as prominent ridges along the ventral surface; and (3) the relative lengths and shapes of the proboscis, collar and trunk.



Saccoglossus kowalevskyi (?). 1, About natural size. 2, × about 5

Previous records of enteropneusts in the British Isles are few in number, and those up to 1939 have been listed by Brambell and Cole[3] in a paper dealing with the anatomy of *S. cambrensis* sp. n. To this list must be added *S. horsti*, another new species, discovered by Goodhart in 1940 at Lymington and described fully in conjunction with Brambell[4].

The incomplete specimen of an enteropneust obtained by Caullery and Mesnil[5] at St. Martin, near Cap de la Hague, was believed by them to be *S. kowalevskyi*; but Brambell and Goodhart are inclined to think that it should have been referred to *S. horsti*. The finding of what appears to be *S. kowalevskyi* at Whitstable re-opens this question, and focuses attention on the problem as to how this and other species of animals so far believed to be confined to the eastern coast of North America have reached the shores of Britain. It is of interest in this connexion to note that the Whitstable specimens were dug from the same situation in which the American maldanid, *Clymenella torquata* (Leidy), was found by me[6]. Both *S. kowalevskyi* and *C. torquata* differ from certain other members of the groups to which they belong in having bottom-dwelling larvæ, and it may be that both species were carried as larvæ to the coasts of Britain with oysters imported from America.

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Conchocelis-Phase in the Life-History of *Porphyra umbilicalis* (L.) Kütz.

SEVERAL investigators, including Janczewski[1], Thuret and Bornet[2], Berthold[3] and more recently Okamura, Onda and Higashi[4], have successfully germinated the carpospores of various species of *Porphyra* and obtained thereby filamentous growths. However, it has never been clearly demonstrated step by step how the leafy thallus originated again, although some workers have succeeded in inducing further growth than others and made observations on which various theories have been based. Grubb[5] describes the liberation of the contents of the terminal cell of a short swollen filament as well as empty swollen tips of others. Both Kylin[6] and Rees[7,8] considered they saw evidence of the formation of monospores on the filaments, and it has been assumed that these germinated into the leafy thallus, although the possibility of such spores reproducing the filamentous stage cannot be ruled out. In Dangeard's[9] view, the filamentous growth is protonemal, the leafy thallus developing on it as 'buds'—a view contested by Rees[7]. At the other extreme, these filamentous growths from the carpospores have been considered pathological by Kunieda[10], who asserts that the carpospores of the Japanese species, *P. tenera* Kjellmann, produced in the spring spend the summer in a resting condition. In the autumn, he considers they germinate direct into the leafy thallus, as do the monospores of all species which have been investigated. An earlier Japanese worker, Yendo[11], described the liberation of ciliated micro- and macrogametes from the original spore as well as other swollen cells of the filamentous growths; but it seems possible such spores belonged to an endophytic fungus.

As a result of experimental work undertaken to clarify the situation and to try to bridge the gap in the life-history of *Porphyra umbilicalis* (L.) Kütz., it has been fully established that, while at times under conditions of culture a few spores remain ungerminated and enlarged, due possibly to the abnormal conditions, the vast majority of the spores germinate a few days after liberation into very distinctive

Fig. 2. Shells with areas infected with *Conchocelis* showing as dark patches. Natural size. Photographed alive under sea water

branched filamentous growths. When such filaments, either at germination or at a much later stage, are brought into contact with old shells, they penetrate the shells and develop rapidly into extensive and highly characteristic growths, apparently identical with an alga known for many years as *Conchocelis rosea* Batters and described so admirably by Batters[12]. This alga is usually obtained by dredging in deep water.

Full details of such experiments will be published in due course together with an account of this extremely interesting *Conchocelis*-phase of the life-history of *P. umbilicalis*; but meanwhile the following facts are brought forward in support of the preceding statement: (1) the germination of several individual spores placed on sterile flakes of shell has been followed until the resulting growths inside the shell flakes were undoubtedly *Conchocelis*. Figs. 1*a*, 1*b* and 1*c* show three stages in the development of one such germling; (2) while almost every sterilized shell on which spores of *P. umbilicalis* have been sown has become infected (often very heavily) with *Conchocelis* (Fig. 2), no *Conchocelis* has developed in similar shells kept under similar conditions but without *Porphyra* spores; (3) at the end of six months in the case of one experiment and just under three months in another, bodies such as Batters described as sporangia for *C. rosea* have been found in such infected shells as have been examined up to date. As these are highly distinctive, it provides conclusive evidence of the correct identification of the shell-boring phase; (4) eight sterilized flakes of shell placed on free-living filamentous growths, two months old, derived from spores of *P. umbilicalis* have been found to contain within a month well-developed growths of *Conchocelis*; (5) the same is true for four pieces of sterilized egg-shell put on the same filamentous growths with marine shell flakes.

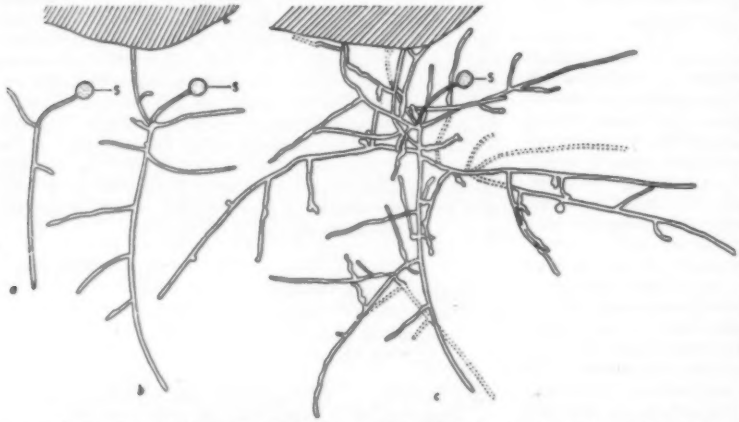

Fig. 1. Development of germling of isolated spore of *P. umbilicalis* placed on flake of shell, May 30, 1949. (*a*) 7 days old, June 6, 1949; (*b*) 11 days old, June 10, 1949; (*c*) 21 days old, June 20, 1949; and now having the typical *Conchocelis* appearance. *s*, Original spore, which together with the filament outside the shell is shaded. Broken lines indicate filaments deep in the shell, and area with oblique lines is thick shell in which it is not possible to trace filaments. (× 105)

It is realized that the gap in the knowledge of the life-history of *P. umbilicalis* is still not completely bridged, and an attempt is being made to follow the development of the very curious so-called sporangia of the *Conchocelis*-phase. These may give rise to further *Conchocelis* or leafy *Porphyra* thalli, but so far sterile shells put in beakers containing well-developed *Conchocelis* remain uninfected by it. Even when the life-history is completely known, the full implications of the existence of this *Conchocelis*-phase cannot be assessed without the cytological evidence, and this side of the investigation has also been started. Dangeard[13] considered that reduction division takes place immediately after fertilization, and if this is so, the existence of the *Conchocelis*-phase is all the more interesting.

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Vibration of the Flagellum of the Ant Antennæ

IN May 1949, a series of photographs of ants of the species *Formica rufa*, Latr., were taken by Raymond Kleboe of *Picture Post*, in collaboration with me, and in many of these worker ants were shown. The ants were usually in a posture of defence; but whether they were defending the nest, attacking prey, or merely hurrying over the surface of the nest or the roads which surround it, the flagella of the antennæ were indistinctly shown in the photographs. The photographs concerned were taken at 1/500–1/1,000 sec.

All the rest of the bodies of these ants were clearly shown, only the flagella being indistinct. These organs, which are thought to have an olfactory function, would seem to be vibrating so rapidly that a camera capable of taking exposures of 1/500 sec. was not able to capture in many cases even a semblance of stillness and clarity. Such movement should, of course, be distinguished from the coarser rotations of the flagella, which are clearly visible to the naked eye.

It is difficult to suggest what functional value such rapid vibration of sensory organs may have, although it would seem that it must be intimately connected with the very high degree of development of the olfactory sense in ants.

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Quantum Yields for Photolysis of the Peptide Bond at 2537 A.

FROM a study of the action of ultra-violet light on monolayers of proteins, Mitchell[1] suggested that tyrosine absorption leads to breakage of the —CONH— bond adjacent to the chromophore. According to Pauling and Niemann[2] the C—N linkage has the lowest bond energy and should, therefore, be the first to break when energy is supplied to the molecule. Mitchell's model experiments for proteins with stearyl anilide suffer from the drawback that the phenyl group is directly adjacent to the —CONH— link, but Carpenter[3] has shown that, with benzyl stearyl amine and β-phenyl ethyl stearyl amine, cleavage also occurs where the benzene ring and the —CONH— linkage are separated by one or two $—CH_2—$ groups.

Since the fragments left by such photolytic cleavage might give valuable clues to the sequence of amino-acids in a protein, it was worth while to investigate the quantum efficiencies of isomeric peptides with the chromophore on opposite sides of the —CONH— bond. A comparison of the action of ultra-violet light (2537 A.) on leucyl-tyrosine and tyrosyl-leucine at different *p*H's was thought suitable, but irradiation under a constant stream of nitrogen showed that no free amino-acids could be detected by the sensitive and specific methods of Van Slyke *et al.*[4]. Although these results contradict a report by Carpenter[5], they are not inconsistent with the findings of earlier investigators[6]. In particular, Guillaume and Tanret did not observe any hydrolysis of the related glycyl-tyrosine after irradiating the solutions for 12 hr. More recently, Weizmann *et al.*[7] found that alanyl-glycine was deaminated like amino-acids, and concluded that relatively no photolysis of the peptide bond takes place whenever free terminal amino-groups are available. Whether such preferential deamination or secondary reactions leading to decomposition of the amino-acids as soon as formed are the cause, photolysis of the dipeptides yielded ammonia but no free amino-acids.

A pair of compounds not containing free terminal amino-groups was considered more desirable for study, since Allen *et al.*[8] and also Levy[9] had shown that acylated amino-acids and peptides are indeed cleaved at the —CONH— bond; also any ammonia produced by photolysis of such hemipeptides must be derived by splitting of the peptide bond. Phenyl-propionyl-alanine and propionyl-phenylalanine were selected to determine whether a preferential transfer of energy in any one direction would take place. Three series of experiments under nitrogen, under oxygen and in air with constant stirring were set up. In all cases *M*/100 solutions, absorbing more than 99 per cent at 2537 A. and having a *p*H *c.* 3, were irradiated. Details of radiation procedures are given elsewhere[10]. The results, shown in the table, show that under nitrogen, within 10 per cent, the energy absorbed by the chromophore is transmitted to the weakest bond, the C—N link of the peptide group, at equal efficiency through 3 C or 2 C and 1 N atom.

This fact may have an important bearing on structure determinations by analysis of fragments obtained by the photolysis of proteins. Somewhat higher quantum yields were obtained in the case of phenylpropionyl-alanine, which yielded small amounts of alanine as well as ammonia. No free phenyl-alanine was found in the irradiated propionyl-phenylalanine solutions, and quantum yields were

	Φ = moles liberated/c.c./hr. / einsteins absorbed/c.c./hr.			
	Gas*	Ammonia	Amino-acid	Total Φ
Phenylpropionyl-alanine	Oxygen	$6{\cdot}3\times10^{-3}$	$0{\cdot}65\times10^{-3}$	$6{\cdot}95\times10^{-3}$ (*a*)
	Nitrogen	$5{\cdot}0\times10^{-3}$	$0{\cdot}12\times10^{-3}$	$5{\cdot}12\times10^{-3}$
Propionyl-phenylalanine	Oxygen	$5{\cdot}8\times10^{-3}$	0	$5{\cdot}8\times10^{-3}$ (*b*)
	Nitrogen	$4{\cdot}5\times10^{-3}$	0	$4{\cdot}5\times10^{-3}$ (*b*)

* Irradiation in air gave the same results as under oxygen.

(*a*) This value is in good agreement with the determinations of Levy (refs. 9 and 10).

(*b*) A comparative study of the photolysis of phenylalanine under the same experimental conditions gave quantum yields of the same order of magnitude.

determined on the basis of the ammonia split off. Under nitrogen, all quantum yields are somewhat lower than under oxygen. Considerable changes in ultra-violet absorption spectra before and after irradiation were recorded in all cases, but Millon tests (tyrosine, 'Dopa') were negative and all solutions remained colourless. Reduction of ammoniacal silver nitrate solution and positive Eegriwe reaction (aldehyde, hydroxy- or keto-acid) were observed.

An interesting corollary of this study is the similarity between the low quantum yields of the model substances and those of intact enzymes and proteins[11].

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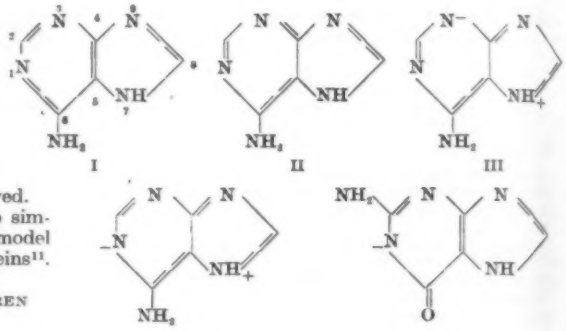
Bond Distances in Adenine Hydrochloride

IN a recent crystallographic study of adenine hydrochloride, Broomhead[1] has concluded that the central or C_4—C_5 bond distance of 1·44 A. is probably significantly greater than those of the other C—C or C—N bonds in the molecule. This conclusion is based on two-dimensional Fourier projections and, as the author states, it is not absolutely certain that the discrepancy cannot be attributed to experimental error. Nevertheless, the result appears to be in accordance with the anomalous second dissociation constant which I have observed[2], namely, $pK'_{a_1} = 4{\cdot}15$, $pK'_{a_2} = 9{\cdot}80$. The former value is of the order to be expected for the amino-group, but the latter, which can only be attributed to the —NH— group of the iminazole ring, is considerably lower than those observed for the corresponding dissociations in benziminazole and in other purine derivatives.

The unusual acidic strength of this group in adenine could be explained if considerable contributions to the structure of the molecule were made, not only by uncharged structures of types I and II, but also by others of types III and IV, in which there is a negative charge on the pyrimidine nitrogen atoms and a positive charge on those in the iminazole ring. This would lower pK'_{a_2} from a value characteristic of an uncharged —NH— group towards one characteristic of a charged group $—\overset{+}{N}H=$; respective values in the case of benziminazole are 12·3 and 5·30, and the observed value of 9·80 in adenine could thus be accounted for. Structures of types III and IV



I to IV, adenine V, guanine (ion)

necessarily contain a single bond in the C_4—C_5 position, and thus account qualitatively for the observed lengthening of the bond.

In the case of purines such as guanine in which oxygen atoms are attached to the pyrimidine ring, the dissociation of the iminazole —NH— group takes place in a molecule which already bears a negative charge in the region of the pyrimidine nitrogen atoms as a result of the dissociation of the —NH—CO— or —N=C(OH)— grouping. Structures corresponding to III and IV would thus be expected to make a smaller contribution to the state of the negatively charged molecule (V) than in the case of neutral or positively charged adenine. In accordance with this view, the pK'_a values of the iminazole —NH— groups in guanine and similar compounds are of the same order as in benziminazole. If this theory is correct, the C_4—C_5 bond distances of the negatively charged molecules existing in solution or as sodium salts should be of normal length. It is possible, however, that when the —NH—CO— grouping is undissociated, as in neutral guanine, or its hydrochloride, the bond distances may be influenced by the different charge distribution. The results of the current X-ray studies mentioned by Broomhead[1] will be of considerable interest.

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The α–β Transformation in a Polypeptide

In an earlier communication[1] we gave evidence for the presence of an α-structure in fibres of two synthetic polypeptides—a copolymer of L-glutamic γ-methyl ester with DL-β-phenylalanine (*A*), and poly-DL-β-phenylalanine (*B*). These fibres were prepared from solutions in *m*-cresol by extrusion into non-solvents. By this method oriented fibres with an α-protein type of structure were prepared, and we suggested that the fold which best fits the crystallographic and infra-red data is that first postulated by Huggins[2] for α-keratin, and later by Ambrose and Hanby[3] to explain the parallel dichroism of the N—H stretching vibrations in poly-L-glutamic γ-methyl ester. (It is interesting to note that the 5·28 A. polar arc of fibre *B* is weak and diffuse, whereas that of *A* is strong and well defined. Qualitatively, therefore, the X-ray results are not inconsistent with the presence of a two-fold screw axis in a symmetrical polymer molecule; see Astbury[4].)

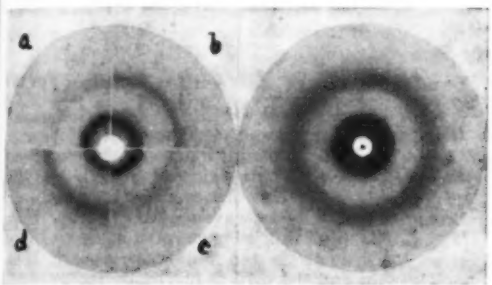

Fig. 1

Fig. 2

Fig. 1. X-Ray photograph of fibres of copolymer of L-glutamic γ-methyl ester with DL-β-phenylalanine: spun from *m*-cresol solution showing α_{II} cry talline configuration (quadrants *a* and *c*): spun from formic acid solution showing β-configuration (quadrants *b* and *d*). Copper *Kα* radiation, *D* = 3 cm.

Fig. 2. X-Ray photograph of fibres of copolymer of L-glutamic γ-methyl ester with DL-β-phenylalanine spun from formic acid and then soaked for 5 min. in *m*-cresol. The diagram is a composite picture showing the disoriented β-phase and an α_{II} oriented phase. Copper *Kα* radiation, *D* = 3 cm.

To prevent confusion at this stage, we propose to use the term 'α_{II}' for the fold, adopted by Huggins and by Ambrose and Hanby, since there are two amino-acid residues per repeat of 5·2 A. Astbury's fold[4], containing three residues in the repeat distance of 5·15 A., postulated for the keratin-epidermis-myosin-fibrinogen group of proteins, is on this basis α_{III}. It is well known that the folded form of this group of proteins can readily be transformed into a fully extended β-configuration. Contrary to this, however, we found that stretching of the synthetic fibres, while leading to orientation of the α_{II} structure, did not produce a β-form. Reasons for this behaviour were outlined in our earlier communication.

We have now found that the copolymer *A* can be spun in two forms, namely, the α_{II} already described, and a β-modification. This latter is obtained when solutions of the copolymer in formic acid are extruded into non-solvents. This form can equally well be obtained by precipitation from formic acid solutions. Fig. 1 compares X-ray photographs of the two modifications of the polypeptide. Fig. 1,*ac* is a powder photograph of the copolymer spun from an *m*-cresol solution into an aqueous medium, and shows a typical crystalline α_{II} structure. Fig. 1,*bd* refers to the same polymer spun into the same coagulating bath from formic acid solution. In this latter diagram there are two intense spacings at 13 A. (side-chain) and 4·65 A. (backbone), and a diffuse reflexion at 3·78 A., which is probably a (210).

Immersion of disoriented β-fibres of the copolymer in *m*-cresol for 5 min. led to two interesting observations: (*a*) partial reversion to α_{II} form occurred, and (*b*) the α_{II} form produced was found to be oriented. Fig. 2 is an X-ray photograph of the fibre after treatment with *m*-cresol. The fine details which appear in the original photograph are shown diagrammatically in Fig. 3, and are as follow. There is a 4·65 A.-spacing of the β-form which is disoriented, and a 5·26-A. polar arc of the α_{II} phase. The inner ring is made up of the disoriented 13-A. spacing of the

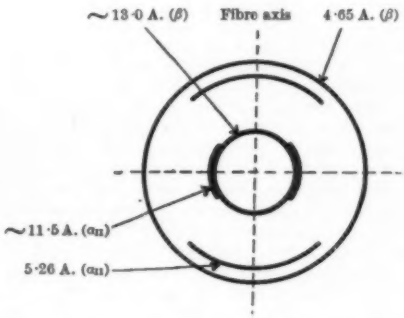

Fig. 3. Diagrammatic representation of X-ray photograph of Fig. 2 showing reflexions from α_{II}- and β-phases in the copolymer

β-form, with the α_{II} equatorial doublet of mean spacing of approximately 11·5 A. showing orientation.

These experiments indicate that it is now possible to prepare this polypeptide in at least two forms. The nature of the α_{II}-form has already been discussed; the X-ray diagram of the second modification is similar to that of extended polypeptide chains in the classical β-form. The orientation produced in (*b*) above is easily understood if the β → α transformation involves a decrease in length of the molecule. Such a contraction would be expected to produce orientation in the same way that stretching a disoriented fibre is known to orient the molecules.

We have examined the effect of the nature of the precipitant and the precise method of regeneration on the configuration of the polypeptide. In the present case it appears that neither factor has much effect. It is therefore reasonable to conclude that the configuration of the polypeptide is decisively influenced by the solvent.

Work with other polypeptides and solvents is proceeding with the view of determining to what extent the above results are otherwise applicable. Evidence which we have accumulated suggests that the ability to produce a β-configuration of this copolymer is not primarily a function of the acid strength of the solvent, and our experience leads us to believe that this ability is connected with the small molecular volume of formic acid. The kinetic

aspects of the subject will be discussed at greater length elsewhere.

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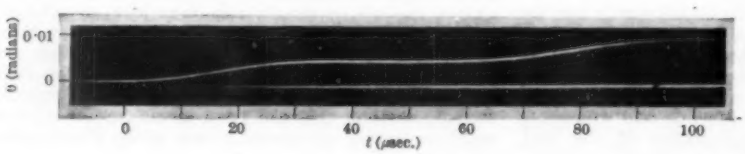
High-Speed Recording by a Rotating-Mirror Method

In the course of a series of experiments on the propagation of transient stress waves in solids, we have developed an optical method of high-speed recording which does not appear to be described in the literature. The duration of the stress pulses is often of the order of 50 microsec., and the only feasible method of recording the phenomena optically is to use a stationary-film camera in conjunction with a mirror rotating at high speed, the recording film being fixed on a circular arc the centre of which lies on the axis of the mirror. If the radius of this arc is 27 cm., a writing speed of 3 mm. per microsec. (measured on the film) will be obtained when the mirror rotates at 1,000 rev. per sec. Rotational speeds of this order of magnitude can be obtained most easily by means of the high-speed air turbines developed for ultracentrifuge work[1], and, in our camera, the rotating mirror consists of an octagonal, stainless steel mirror mounted on the rotor of a small turbine of this type.

The camera can be put to many uses, and a typical example of its application is the investigation of the propagation of torsional waves in steel cylinders; for this purpose, a minute optical flat was polished on the surface of the bar and the variation of the angular deflexion, θ, of this flat with time, t, was recorded by reflecting a narrow pencil of light from it to the rotating mirror and thence to the recording film. A stress pulse consisting of torsional waves was initiated by firing a rifle bullet at a suitable point on a flat surface machined on one end of the bar, and a typical record obtained under these conditions is shown in the accompanying figure.

The lower trace is a datum line obtained when the bar was at rest. The upper trace shows the stress pulse reaching the recording mirror at $t = 0$ and ending at $t = 35$ microsec.; θ then remains constant until $t = 60$ microsec., when the pulse returns to the recording mirror after reflexion at the free end of the bar. The reflected pulse ends at $t = 95$ microsec.



The time-scale of the record was calculated from the geometry of the apparatus and the speed of rotation of the turbine, which, in turn, was measured by determining the frequency of the signal from a photocell illuminated by a beam of light reflected from the rotating mirror.

The light source used in the experiments was a mercury flash tube energized by the discharge of a condenser. The duration of the flash was arranged to be about 100 microsec., and the flash was synchronized with the arrival of the stress-wave at the recording point by a ring-switch and thyratron circuit similar to that described in another connexion[2].

One of us (J. D. O.) is indebted to the Department of Scientific and Industrial Research for a maintenance allowance.

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Band Systems of Zirconium Oxide (ZrO) in the Ultra-Violet

Three new systems of ZrO have been observed in the ultra-violet, in addition to the three triplet systems in the visible region analysed by Miss Lowater[1]. Lowater also observed twelve bands, degrading to the longer wave-length, in the region 3726–3470 A., differing in general appearance from the triplet systems in the visible, the bands being much weaker and the triplets not easily recognizable. Although thirty-one bands have been measured in the ultra-violet by us, only five of the twelve band-heads measured by Lowater agree with ours. As the atomic spectrum of zirconium in this region is particularly strong, and as the lines are numerous, weak lines have apparently been mistaken for band-heads. However, it has been possible to photograph the ZrO spectrum in the region 2930–6700 A. remarkably free from lines, and to identify the real band-heads. Altogether thirty-one bands were measured in the region 4000–2930 A., and assigned to one singlet and two triplet systems.

The source was a 110-volt D.C. arc running at 4 amp. The lower electrode was of copper, and shaped into a cup of thin walls with a neck of 1·5 mm. at the bottom. This was filled with zirconium fluoride and made the anode. The cathode was a thick copper electrode flattened at the bottom to effect rapid cooling. The temperature in the anode cup was kept just below the temperature of rapid oxidization. Vapours rising from the molten zirconium fluoride in the anode cup showed strong bands of ZrO on oxidization just below the cathode. The atomic spectrum of zirconium in this source was very weak. The following systems were photographed.

(1) The λ 3682 and λ 3589 bands, now forming the (0,0) and (2,1) bands of the singlet system, were measured by Miss Lowater. The λ 3682 band has also been observed in the spectra of the late-type

stars by Merrill[2] and Joy[3]. Quite recently, Herbig[4] discovered the band at λ 3682 on a plate taken by King in the first order of 20-ft. grating (dispersion 3·7 A./mm.), the source being the envelope of a carbon arc, one of the poles of which had been charged with zirconium oxide; and thereupon attributed the absorption band at λ 3682 in the stellar spectra to ZrO. In addition to this band in the late-type stars, he also observed the absorption feature of a band-head at λ 3571 A. As will become evident later on, this is the strong (1,0) band of the singlet system. After measuring about 130 lines in the λ 3682 band, Herbig arranged them into a P and an R branch, and concluded that the band was due to a $^1\Sigma - {}^1\Sigma$ transition. The failure to observe any isotopic shift was explained by assuming the band to be the (0,0) band of the system. In the spectrogram published by him, and in the plates taken by me, the P and R branches are very weak, and are not quite resolved either near the band origin or near the band-head. It is therefore possible that a faint Q branch in a $^1\Pi - {}^1\Pi$ transition may not become observable among weakly photographed P and R branches. The transition responsible for this system, therefore, remains doubtful. In our opinion, it also appears unlikely that the lower level of this system could be the ground state of ZrO.

In all, nineteen bands constituting six separate sequences were measured for this system. The strong bands of the different sequences are listed below.

λ_{air}	Int.	v',v''	λ_{air}	Int.	v',v''
3981·45	(3)	1,3	3589·87	(6)	2,1
3818·32	(4)	0,1	3571·96	(8)	1,0
3700·11	(1)	1,1	3486·71	(2)	3,1
3682·07	(10)	0,0	3390·05	(1)	4,1

The formula relating the nineteen heads of this system is:

$$\nu_A u',u'' = 27217{\cdot}92 + [843{\cdot}75\,u' - 3{\cdot}15\,u'^2] - [978{\cdot}07\,u'' - 5{\cdot}04\,u''^2 + 0{\cdot}072u''^3] - 0{\cdot}90\,u'u'' \text{ cm.}^{-1},$$

where $u = v + \frac{1}{2}$.

(2) Six band-heads all belonging to the (0,0) band of a triplet system were observed at λ 3472–3507 A. From their appearance they were considered to be the R_1, Q_1, R_2, Q_2, R_3, and Q_3 heads. The nature and the positions of the states responsible for this system are not very certain. If the lower level is assumed to be the $^3\Pi$ ground state of ZrO, the upper one is likely to be a $^3\Delta$ state, with sublevel differences of 473·6 and 410·8 cm.$^{-1}$. The transition responsible for this system may, therefore, be $^3\Delta \rightarrow {}^3\Pi$. Details of the bands are given below.

λ_{air}	Int.	v',v''	λ_{air}	Int.	v',v''
3507·56	(1)	$0,0Q_3$	3491·80	(3)	$0,0R_3$
3506·30	(3)	$0,0R_2$	3473·62	(1)	$0,0Q_1$
3493·06	(1)	$0,0Q_2$	3472·39	(3)	$0,0R_1$

It should be noted that all the three R heads of this system were observed by Miss Lowater.

(3) Six band-heads were measured in the region λ 2940–3060 A. and assigned to a triplet system $^3\Pi \rightarrow {}^3\Delta$. The system is very weak, and only three R heads of the (0,0) band and the three R heads of the (0,1) band were observed. The presence of the (0,1) band enabled the lower state to be identified with the $^3\Delta$ ground-state of ZrO. The differences between the upper triplet levels are 110·1 and 186·8 cm.$^{-1}$. The details are as follow:

λ_{air}	Int.	v',v''	λ_{air}	Int.	v',v''
3052·4	(1)	$0,1R_3$	2967·8	(2)	$0,0R_3$
3033·5	(1)	$0,1R_2$	2950·0	(2)	$0,0R_2$
3023·8	(1)	$0,1R_1$	2940·9	(2)	$0,0R_1$

I should like to express my gratitude to Prof. R. W. B. Pearse, for suggesting the problem and supervising the work.

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[1] *Proc. Phys. Soc.*, **44**, 51 (1932).
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Ultra-Violet Absorption Spectra of Rubidium and Cæsium Fluorides and the Heat of Dissociation of Fluorine

Until recently, the dissociation energy of molecular fluorine was believed to be about 63 kcal./mole[1]. Within the past few years, however, evidence—based in particular upon spectroscopic[2,3] and thermochemical[2,4] studies of ClF—has accumulated to suggest that $D(F_2)$ is much lower. Thus, a mean value for the heat of formation of ClF at 18° C. is 12·3 ± 1 kcal.: combining this with the value of D_{18}(ClF), 61·2 ± 0·5 kcal. or 59·8 ± 0·5 kcal. (according to the state of excitation of the atoms on dissociation of excited ClF) leads to $D_{18}(F_2) = 40{\cdot}_6$ or $37{\cdot}_2 \pm 3$ kcal.

A value of $D(F_2)$ so much lower than that of D(ClF), and indeed than that of $D(Cl_2)$, is at first sight surprising. We have, therefore, attempted to measure it in a new way through rubidium and cæsium fluorides. $D(F_2)$ is linked thermochemically in cycles involving $D(MF)$ and the heats of formation of MF, $Q(MF)$. If L stands for a latent heat of vaporization,

$$\tfrac{1}{2}D(F_2) = D(MF) + L(MF) - L(M) - Q(MF).$$

It turns out that $D(MF)$ may be determined from the ultra-violet absorption spectra.

We have photographed the absorption spectra of rubidium and cæsium fluorides on Hilger small and medium quartz spectrographs. Continuous absorption is detectable at a pressure of about 4 mm. in an effective path of about 20 cm.: the corresponding temperatures are about 900° C. for rubidium fluoride and 750° C. for cæsium fluoride. At this stage the absorption is confined to a small region some 50 A. in extent: the maximum absorption occurs at about 2150 A. for rubidium fluoride and 2100 A. for cæsium fluoride. As the temperature is raised, diffuse bands appear at longer wave-lengths: in the spectrum of rubidium fluoride some thirty bands extending to 2980 A. have been measured, and for cæsium fluoride, twenty-five bands going up to 2710 A. From these observations it has been possible to deduce what are thought to be rather accurate values of D_{18}(RbF) and D_{18}(CsF) (Table 2). The detailed analyses will be published later.

The heats of formation, $Q(MF)$, are also known with considerable accuracy[5], so that in order to compute $D_{18}(F_2)$, it is now only necessary to consider the latent heats of sublimation of the metals and of the fluorides. The vapour pressures of the metals have been reviewed by Ditchburn and Gilmour[6]: the values of $L_{18}(M)$ seem likely to be correct to about ± 2 per cent[6]. The values of $L_{18}(MF)$ are less certain, as the vapour pressures are known only at high

temperatures[7,8]. To reduce $L_T(MF)$ to $L_{18}(MF)$ we use:

$$L_{18}(MF) = L_T(MF) + L_f(MF) + \frac{5}{2}R\Delta T + \frac{\alpha^2 V}{2\beta}\ \Delta(T^2) - \int_{291}^{T} C_{vib.}dT,$$

where L_f is the latent heat of fusion. The values taken for these quantities are given in Table 1.

Table 1: Data for $L_{18}(MF)$

	Cæsium fluoride	Rubidium fluoride
L_T	34·15 (1,375° K.)	40·2 (1,550° K.)
L_f (estimated)	5·7	6·1
$\frac{5}{2}R.\Delta T$	5·90	6·25
$\frac{1}{2}\Delta(T^2)\frac{\alpha^2 V}{\beta}$	1·93	2·01
$-\int_{291}^{T} C_{vib.}dT$	−1·99	−2·35
L_{18}	45·7	52·2

The error in L_{18} is estimated at about $\pm$ 2·5 kcal. $D_{18}(F_2)$ may now be calculated. The values are given in Table 2.

Table 2

	D_{MF}	L_{MF}	L_M	Q_{MF}	D_{T_1}
Rubidium fluoride	126·1 ± 1·5	52·2	18·9	133·2	52·4
	124·9 ± 1·5				50·0
Cæsium fluoride	130·7 ± 0·5	45·7	18·8	131·7	51·8
	129·5 ± 0·5				49·4

The errors in the final values of $D(F_2)$ are estimated to lie within about $\pm$ 6 kcal.: the higher value from each salt is based on the assumption of dissociation into $F(^2P_{3/2})$, the lower values on dissociation into $F(^2P_{1/2})$.

The new figure, 50 $\pm$ 6 kcal., for $D(F_2)$ is incompatible with the only other direct result, that of 40 $\pm$ 3 kcal., from ClF. In both determinations, the spectroscopic data appear to be satisfactory, so that suspicion falls (i) on the thermochemical data used in the alkali fluoride cycles; (ii) on the value of the heat of formation of ClF. As to (i), it seems satisfactory that the results from the two salts are in such reasonable agreement, but it is possible that the errors lie in the same direction in both cases. It may be observed that the greater part of the uncertainty here arises from the computation of $L_{18}(MF)$: it should be possible substantially to reduce this by low-temperature measurements of the vapour pressures of the solid salts. Until this is done, it will not be possible to use the new values of D(RbF) and D(CsF) to determine a precise value for $D(F_2)$. Nevertheless, the present work does support a 'low' value of $D(F_2)$, and it seems certain that the bond strength of molecular fluorine is less—perhaps considerably less—than that of molecular chlorine.

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Interferometric Study of Slip Bands on Metal Crystals

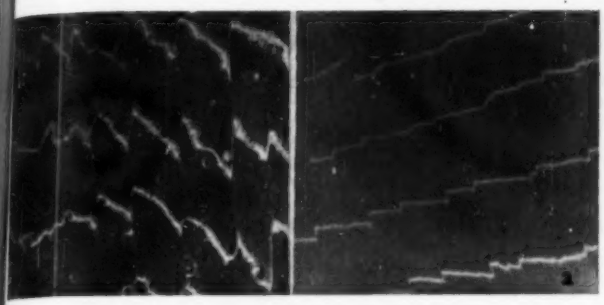
We have applied multiple-beam interference methods to the study of the displacements which may be expected to appear on the surfaces of metal crystals when strained, and this technique has revealed novel features. The principal advantages resulting from using this technique are fourfold: (i) the detailed contours of displacement steps are clearly revealed; (ii) exact evaluation of displacements of even but a few angström units can be made; (iii) owing to high sensitivity, the onset of the slip is shown at a very early stage; (iv) slip with abnormally low loads can be detected.

The method has been successfully applied to aluminium and tin, and this preliminary note is intended to show the considerable power of the technique and indicate its potentialities. Owing to the optics involved, the features to be studied must at present extend over at least 1/250 mm. across the surface. In the case of aluminium, a bar was heat-treated to produce large crystal units, and, after being ground flat, it was electrolytically polished. Small loads, up to a maximum of 0·25 kgm./mm.^{2}, were applied, and as a result, widely spaced, more or less parallel, slip lines appeared, separated by distances of between 1/20 and 1/50 mm. On matching against a suitably prepared optical flat, multiple-beam reflexion fringes can be formed, an example being shown in Fig. 1. (The linear magnification in extension is × 150.) The fainter vertical markings are the slip lines, and the fringes run across roughly in the horizontal sense. Three features are at once apparent: (*a*) the average 'step' value is of the order of 900 A.; (*b*) the blocks between slip zones appear to have tilted through angles of the order of 6 minutes of arc; (*c*) the blocks show distinct evidence of a superposed secondary structure.

We have no facilities for X-ray determination of crystal orientation, hence a numerical analysis is scarcely profitable; but this position is now being rectified and a detailed programme is projected.

Fig. 2 shows the slip steps (at × 150) obtained with tin, and these fringes are of especial interest. To obtain a tin surface of high optical quality, recourse was made to a simple casting technique. (We had the benefit of discussion with Dr. Hedges of the Tin Research Association in this matter.) Pure molten tin was cast against a polished plate-glass disk of high-grade optical quality. We find that the tin moulds itself against the glass and partakes of its form and its high polish. So close is the adherence that removal of the tin without producing some slight strain is difficult. A good method is to cut a scratch on the back of the glass with a glazier's diamond. On snapping the glass in two, the tin is released. It is found to have a perfect 'polish', and, of course, all the cold-work surface anomalies produced by mechanical polish are avoided. Furthermore, the reflectivity is high (exceeding 80 per cent), so that conditions are ideal for the production of very sharp fringes. The metal usually shows a few large separate crystal grains and often exhibits a few widely spaced slip lines, produced by the slight strain caused during separation of the cast specimen from the glass.

The special features of Fig. 2 are as follows: (*a*) the fringes are of exceptionally fine quality, due to the high reflectivity and the condition of 'polish'; (*b*) between slip lines the surface quality is un-



doubtedly as good as the polished glass used for the casting; (c) slip steps observed range from less than 30 A. to 350 A. (± 20 A.) on the particular specimen under observation.

The detection of the smallest of the steps is only possible because of the high quality of the fringes, and we strongly emphasize here the considerable optical value of this new casting technique. We are, for example, in this laboratory, making a re-determination of some of the optical constants of tin, using a cast surface. The method can clearly easily be used with all the lower melting point metals and alloys. There is, of course, no question of a Beilby layer, and, in fact, we intend studying the effect of mechanical polish on such a virgin surface, which is ideal for the purpose.

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A General Powder X-Ray Photography

At the outset of calculation, no assumption whatever is made as to the symmetry and dimensions of the unit cell. The powder photograph is simply treated as that of a triclinic crystal without special relationship between its constants. The reflexion hkl in the powder photograph, then, may be expressed in terms of its reciprocal lattice[1], thus:

$$Q_{(hkl)} = \frac{4\sin^2\theta}{\lambda^2} = h^2a^{*2} + k^2b^{*2} + l^2c^{*2} + 2klb^*c^*\cos\alpha^* + 2lhc^*a^*\cos\beta^* + 2hka^*b^*\cos\gamma^*,$$

where θ is the Bragg angle observed, λ the wave-length used and $a^*, b^*, c^*, \alpha^*, \beta^*, \gamma^*$ are the reciprocal axial lengths and angles to be determined.

Take any triplet of observed lines for 100, 010 and 001 reflexions[2]. This would determine immediately the three reciprocal axial lengths a^*, b^*, c^*. Next draw in the diagram an imaginary line just where the $h0l$ (or $h0\bar{l}$) reflexion would appear if the β^*-angle were to be discarded, namely,

$$Q'_{(h0l)} = h^2a^{*2} + l^2c^{*2}.$$

The reflexions $h0l$ and $h0\bar{l}$ will be in positions exactly symmetrical to each other across this line, as may be seen from the formulæ:

$$Q_{(h0l)} = h^2a^{*2} + l^2c^{*2} + 2lhc^*a^*\cos\beta^*$$
$$Q_{(h0\bar{l})} = h^2a^{*2} + l^2c^{*2} - 2lhc^*a^*\cos\beta^*.$$

When these reflexions do actually occur in the photograph, they will enable us to determine the β^*-angle, namely:

$$\cos\beta^* = \frac{Q_{(h0l)} - Q_{(h0\bar{l})}}{4lhc^*a^*}.$$

If, on the contrary, no pair of such reflexions is available with a variety of combinations of h and l, we choose another triplet of reflexions as the unit reflexions 100, 010 and 001 or eventually as their higher-order reflexions $h00$, $0k0$ and $00l$ and repeat the same process; and similar ones also with regard to the remaining reciprocal axial angles until all three of α^*, β^*, γ^* together with a^*, b^*, c^* are found. In a favourable case a few trials will suffice to achieve this.

With the reciprocal constants known, we can now assign indices to the complete set of lines of the powder photograph. A survey of the calculated and observed Q-values listed for each reflexion will decide whether or not we have determined correctly the constants of the reciprocal lattice. If necessary, they should be corrected by trial and error to such a degree that no serious discrepancies between the observed and calculated Q-values exist throughout the entire range of reflexion.

These constants are, of course, except by coincidence, the unique ones that are characteristic of the lattice. In order to obtain them, the ternary quadratic form with these constants as its coefficients must be subjected to reduction[3]. We follow for that purpose the procedure devised by Delaunay[4]. It not only leads to the ultimate set of constants but also reveals the type of the lattice. From the constants of the reciprocal lattice, those of the (direct) lattice may readily be calculated using the usual formulæ[5].

$\sin^2\theta$obs. (Bystrom)	Qobs. (λ = 2·29 A.)	Qcalc.	$h'k'l'$ (as triclinic)	hkl (rhombic)
0·0895	0·0685	0·0686	100	002
0·1092	0·0836	0·0833	010, $1\bar{1}0$	101, $\bar{1}01$
0·1220	0·0934	0·0928	001, $20\bar{1}$**	012, $0\bar{1}2$
0·1263	0·0967	0·0968	$\bar{2}02$	020
0·1404	0·1074	0·1075	$01\bar{1}$*, $11\bar{1}$, $\bar{1}11$, $\bar{2}11$	$1\bar{1}\bar{1}$, $1\bar{1}1$, 111, $11\bar{1}$
0·3201	0·2450	0·2447	011*, $1\bar{1}1$, $21\bar{1}$, $\bar{3}11$	113, $\bar{1}13$, $1\bar{1}3$, $11\bar{3}$
0·3455	0·2644	0·2646	$\bar{1}20$***	200
0·7048	0·5394	0·5390	$\bar{3}20$, 120***	$\bar{2}04$, $20\bar{4}$
0·8388	0·6419	0·6416	$40\bar{1}$, $20\bar{1}$**	$0\bar{1}6$, 016

N.B. Only part of the calculated results is here reproduced. Pairs of observed lines used for the determination of the reciprocal axial angles are marked respectively with * ** ***.

We have tested the feasibility of the present procedure in several cases with satisfactory results. The only requirement for success is that we have a good enough photograph with individual Debye lines well resolved and with errors uniformly distributed over the range of experiment. We append as an example the result of calculation carried out on data (PbF_2) from Westgren's laboratory in Stockholm[6]. Calculation has led to a 'triclinic' lattice (see table) with $a^{*2} = 0{\cdot}0686$, $b^{*2} = 0{\cdot}0833$, $c^{*2} = 0{\cdot}0928$, $b^*c^*\cos\alpha^* = 0{\cdot}0343$, $c^*a^*\cos\beta^* = 0{\cdot}0686$, $a^*b^*\cos\gamma^* = 0{\cdot}0343$. Upon reduction these give the lattice with $a^{*2} = 0{\cdot}0833$, $b^{*2} = 0{\cdot}0242$, $c^{*2} = 0{\cdot}0833$, $b^*c^*\cos\alpha^* = 0$, $c^*a^*\cos\beta^* = -0{\cdot}0490$, $a^*b^*\cos\gamma^* = 0$.

This apparently monoclinic simple lattice is no other than a rhombic B^*-centred lattice with $a^* = 0{\cdot}25720$, $b^* = 0{\cdot}15556$, $c^* = 0{\cdot}13096$. These give finally $a = 3{\cdot}888$ A., $b = 6{\cdot}428$ A., $c = 7{\cdot}636$ A., which compare favourably with $a = 3{\cdot}889$ A., $b = 6{\cdot}428$ A., $c = 7{\cdot}633$ A. as given by Byström. The (direct) lattice is again B-centred. The rhombic indices hkl are related to the triclinic indices $h'k'l'$ as follows: $h = k'$, $k = l'$, $l = 2h' + k' + 2l'$. The details of the calculation will be published elsewhere.

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Specific Ionization of Extensive Shower Particles

In using ionization chambers to study extensive showers, it is necessary to assume some value for the specific ionization of shower particles in order to convert the number of ions collected (which is the quantity measured by the chamber) to the number of particles passing through the chamber, and hence the shower density. There seems to be no general agreement between different workers as to the best figure to assume for this purpose. A survey of the literature reveals that values range from 50 to 100 ion pairs/cm. for air. Many are in the vicinity of 85 ion pairs/cm. for argon, or its equivalent of about 65 ion pairs/cm. for air or nitrogen. This figure corresponds to the specific ionization averaged over electrons of all energies, including those near the minimum of the ionization loss – energy curve. The average energy of extensive shower particles is in the region of 100 MeV., and it therefore seems reasonable to take a larger value for the specific ionization of such particles. Carmichael[1] has, in fact, suggested that discrepancies between the extensive shower spectrum obtained by Geiger-counter methods and that found from the size distribution of large bursts could be partly due to an under-estimation of the sizes of bursts in the latter case for the above reason. Carmichael suggests that a value of specific ionization at least 1·4 times greater is necessary to obtain agreement.

In connexion with ionization-chamber experiments conducted in this laboratory, an estimate (based on published data) was made of the specific ionization of electrons of 100 MeV., and is published in the belief that it will be of use to other workers in this field.

Direct measurements for electrons in this energy region have been made by Corson and Brode[2], Sen Gupta[3] and Hazen[4]. In all cases the method employed was that of drop-counting in a cloud chamber filled with nitrogen. From their results we obtain an average value of 59 ± 5 ion pairs/cm. for the probable specific ionization in dry nitrogen at N.T.P. for electrons of energy 100 MeV. Corson and Brode do not state whether their results were corrected for the ionization of the water and alcohol vapour in the chamber. If not, the average would be reduced to 58, but this is well within the probable error.

Cloud-chamber techniques measure only the 'probable' ionization, that is, the primary ionization plus ionization from secondaries of energy less than a certain critical value, which is about 10^4 eV. At 100 MeV. the *total* ionization for electrons (which includes that from all secondaries) is 1·4 times greater than the probable ionization as measured in cloud chambers[1]. The total ionization for extensive shower electrons is thus 83 ion pairs per cm. for nitrogen, corresponding to 107 for argon. It may be noted that this value of specific ionization, although 1·3 times greater than values commonly used, is still not sufficient to bring ionization-chamber and Geiger-counter measurements into agreement.

Ionization chambers, at least for high pressures, measure a quantity which is close to the total ionization. For any given ionization chamber there will be an average upper limit η to the energy of secondaries that expend all their energy in producing ions in the chamber. Secondaries of higher energy will escape from the chamber without losing all their energy in the production of ions. The actual value of η differs from chamber to chamber, being dependent upon the geometry of the chamber and the nature and pressure of the gas. The accompanying table shows the calculated probable ionization for ionization chambers as a percentage of the total ionization for electrons of 100 MeV., on the assumption that ionization from secondaries of all energies less than η eV. is completely collected.[6] Secondaries of energy greater than η will lose some part of their energy in the chamber, the amount lost by a secondary the energy of which lies between E' and $E' + dE'$ being approximately:

$$\frac{\eta^2}{E'^2} \cdot dE' \text{ eV.} \quad (E' > \eta).$$

The amount of energy *not* expended within the chamber can be calculated by appropriately modifying the relation 1·8 of Rossi and Greisen[5]. The percentage of the total energy of the secondaries detected by the chamber follows at once.

Percentage total ionization for secondaries of energy less than η eV. Primary energy, 100 MeV.

η (eV.)	Percentage total ionization
10^4	74
2×10^4	76·3
5×10^4	79
10^5	81
2×10^5	83·3
5×10^5	86
10^6	88

The work described above was carried out as part of the programme of the Nuclear Physics Section of the Council for Scientific and Industrial Research, Australia.

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Isotopic Tracer Elements and Stereochemistry

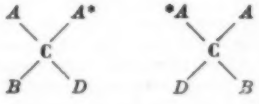
THE interpretations which Ogston[1] has placed on certain tracer experiments on metabolic processes have aroused widespread interest in the role of tracer elements in stereochemistry. Ogston's concept has recently been substantiated in the case of citric acid by the experiments of Potter and Heidelberger[2]. It has implications, however, which go beyond the specific biochemical experiments cited by Ogston.

A general rule has been proposed[3] which may be useful in tracer experiments with asymmetric reagents, whether or not these reagents are enzymes. The following rule will apply to any *partial asymmetric synthesis* or decomposition.

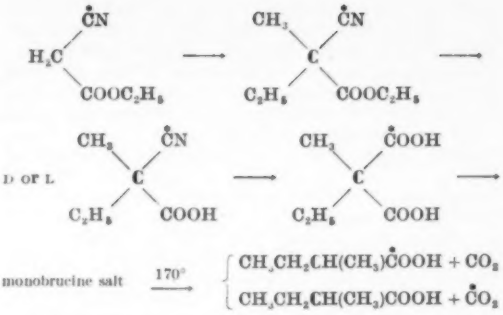
In a molecule which has a plane of symmetry or a point of symmetry, if one of the atoms which does not lie in any plane or point of symmetry is replaced by an isotopic atom, the molecule becomes asymmetric with respect to the labelled atom. In any reaction with an asymmetric reagent, this labelled atom (or group) may react at a rate which is different from that of its counterpart through the plane or point of symmetry, and the difference in rates will be expressed in the distribution of the isotope in the products.

This asymmetric behaviour would be superimposed on any difference in the rates of reaction which would result from the different masses of the isotopic atoms. Stereoisomerism which leads to such asymmetric behaviour of labelled atoms or groups in otherwise symmetric molecules might be designated 'isotopic pseudoasymmetry', since it is analogous to the pseudoasymmetry which results from optical isomeric groups. Isotopic pseudoasymmetric molecules could be produced either by enzymatic reactions or by chemical synthesis, which would necessarily involve the resolution of structurally asymmetric intermediates.

The special case of asymmetry about a carbon atom is of particular interest. Consider the tetrahedral carbon atom carrying two structurally similar groups, *A*, and a third and fourth group, *B* and *D*, respectively, which are dissimilar. If one (or both) of the similar *A* groups is involved in reaction with an asymmetric reagent, the carbon atom with the two similar groups will become asymmetric and the intermediate complex will behave as a diastereoisomer. Then the *A* groups are no longer equivalent and may undergo a subsequent reaction at different rates, or one may react almost exclusively in an enzymatic reaction as proposed by Ogston[1]. The asymmetric behaviour of the *A* groups would be detected if one of them were labelled by an isotopic atom. In this case the two isotopic stereoisomers can be represented as follows:



Tracer techniques are being used here in a re-investigation of the work of Marckwald[4] on the partial asymmetric synthesis of 2-methylbutyric acid from ethylmethylmalonic acid in order to test the validity of the proposed rule in a non-enzymatic system. (For an excellent discussion of the classic work of Marckwald, see Ritchie[5].) For example, the following series of reactions are being investigated:



Marckwald demonstrated that heating the L-brucine salt of ethylmethylmalonic acid to 170° decarboxylates the acid to give optically active 2-methylbutyric acid, 55 per cent lævorotatory and 45 per cent dextrorotatory. It would be expected that the distribution of the isotopic atom would be affected to a similar extent. The results of these experiments will be forthcoming shortly.

I am indebted to Prof. Karl Paul Link for his interest in the investigation.

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Action of Beta Amylase on Amylose

IN a recent paper, Hopkins, Jelinek and Harrison[1] have studied the hydrolysis of potato amylose to maltose with the enzyme, beta amylase. These workers found that the hydrolysis proceeds at a continually diminishing rate and that it is never a first-order reaction as has been claimed by some workers[2,3]. From a study of the products at various stages of the hydrolysis, the theory advanced to explain the facts is that the longer chains of amylose are hydrolysed at a faster rate than short chains and that the longer chains are attacked first. This would account for a continually diminishing rate of hydrolysis as the reaction proceeds and as the length of the chains gradually becomes shorter. From data presented in a recent paper[4], and from other considerations which were briefly mentioned at that time, we have presented a rather different view to explain similar observations.

We are agreed that the reaction is not of zero order, except under certain limiting conditions, and that the rate-constant decreases somewhat even when the equation for a first-order reaction is applied to the hydrolysis as ordinarily performed at a low ratio of enzyme to amylose. We have noted[5], however, that the hydrolysis approaches a first-order reaction under certain conditions, particularly in the case of the hydrolysis of a highly purified corn amylose sample, actually a corn amylose subfraction, which we know to have a DP_n of the order of 225 glucose units[6]. The whole corn amylose fraction (butanol

precipitate of gelatinized corn starch) has a DP_n of the order of 450–500. Furthermore, we have also reported that under the same fixed conditions, including equal weight concentration of amyloses, the monomolecular reaction-constant for the amylose of DP_n 225 is $9{\cdot}8 \times 10^{-3}$ at zero time, whereas the initial value for a sample of DP_n 455 is $4{\cdot}2 \times 10^{-3}$. Thus, it would appear that the apparent rate is determined first of all by the number of non-aldehydic end-groups per unit volume presented by the amylose fraction. However, even taking this difference into consideration, it appears that there is a slight difference in favour of a more rapid hydrolysis of shorter chains. This may be explained, possibly, on the basis of more rapid diffusion of the shorter chains which enable them to come into contact with the enzyme more quickly. An alternative explanation is, of course, that some of the longer chains are not perfectly linear.

Upon examination of the unconverted residues at various stages of the hydrolysis of corn amylose of DP_n 455, it was found, surprisingly enough, that the chain-length value had not materially decreased. Analytically, the products of conversion could be accounted for on the basis of only maltose and chains of almost the same average chain-length as before the start of hydrolysis. Apparently partially hydrolysed chains did not exist in sufficient quantities to affect the analytical results.

From these findings, we proposed that, after having made contact, the enzyme hydrolyses an amylose molecule completely to maltose before beginning the attack on another molecule. It would seem to follow also that the time for actual hydrolysis of an amylose molecule was extremely short, compared to the time required for the enzyme and amylose to diffuse so that they could make contact.

Thus, under the usual conditions of a low ratio of enzyme to amylose, the reaction could scarcely be expected to be of zero order since the effective substrate concentration, which is the concentration of amylose end-groups, does not remain constant, as postulated by Meyer[3], but is continually decreasing as each amylose molecule is completely eliminated in turn as maltose molecules. The reaction should approach a first-order reaction as indicated by Kerr and co-workers, and this it appears to do in the case of corn crystalline amylose (with a DP_n of 225) as well as in the early stages for whole corn amylose. With extended times of conversion there are other matters to take into consideration—the colloidal stability of the amylose, the stability of the enzyme at very low concentration to acidity and temperature of the reaction mixture, the number of times an enzyme may complete a cycle of complex formation with substrate, hydrolysis and dissociation at the aldehydic end without losing activity, and the possibility that some molecules in the amylose fraction may, more than others, resist the action of the enzyme. Individually, these effects may be small, particularly under properly controlled conditions, but collectively they may exert some effect in retarding the reaction.

It is of interest to note that, from an entirely different approach, namely, a study of the activation of phosphorylase by amylose hydrolysates and other data[7,8,9], Swanson and Cori arrived, independently, at the same conclusion that during the hydrolysis of amylose with beta amylase there are no partially hydrolysed chains, in any significant concentration, and presented the same interpretation for the action of beta amylase as has been given above, including a preferential hydrolysis of shorter chains.

As additional and perhaps incidental considerations, it may be remarked that one of the postulates of Hopkins, Jelinek and Harrison, on which their theory of enzyme action was developed, is not entirely in accord with our observations. Contrary to the implications of Meyer and co-workers[10,11,12], the longest amylose chains do not retrograde or associate or aggregate most readily. Of the naturally occurring amylose molecules, it has been our experience that those with a chain-length of the order of corn crystalline amylose with a DP_n of 225, and perhaps of slightly shorter chain-lengths, retrograde at a maximal rate. Subfractions of corn amylose and of potato and tapioca amyloses with DP_n values in higher ranges, 400–1,000, aggregate more slowly, as do their products of acid hydrolysis with chain-lengths of DP_n 50 and less. Therefore, if all amylose molecules are linear polymers, then, as originally proposed by Meyer[13], there is a chain-length which is optimum for retrogradation. It is now known that this value is in the range of DP_n 150–200.

The beta amylase hydrolysis experiments of Swanson were virtually completed in three hours, and even under these conditions the actual hydrolysis was so rapid that chains of intermediate length were not found either in phosphorylase activation experiments, by dialysis, or by change in the wave-length of maximal adsorption for the iodine complex, except in the last phases of the reaction. On this basis, in hydrolyses which extend beyond five hours such as those performed by Bernfeld and Gürtler[11], the assumption that a large excess of enzyme was present in the sense that the number of enzyme molecules was sufficient to form reaction complexes with all amylose molecules, almost immediately, scarcely seems to be a satisfying one; nor is the added assumption that complete hydrolysis of amylose to maltose was obtained in these specially designed experiments, due to the fact that the amylose was from the start in complex formation with the enzyme and was partially degraded from its very high molecular-weight level to an intermediate range before it had an opportunity to retrograde. Actually, as related above, corn amylose (butanol precipitate of whole corn starch) is more colloidally stable than chains of shorter length. It seems probable that extraordinarily high limits of conversion for whole amylose fractions, often reportedly 100 per cent, may frequently be due, as pointed out by Swanson, to incorrect methods for measuring the extent of hydrolysis.

The results of Hopkins, Jelinek and Harrison[1] showing, as hydrolysis proceeds and unconverted amylose residues are recovered from the reaction mixture and are again treated with beta amylase, that the further hydrolysis had proceeded in the initial reaction the more difficult it was afterwards to convert the residues to maltose, lend themselves to an alternative interpretation. It seems more logical now to conclude that the unconverted residues represent a progressive concentration of starch molecules, with which the enzyme has had more difficulty in forming a reaction complex because of some anomaly in structure or configuration. On this basis, these results create considerable doubt that the whole amylose fractions are completely converted to amylose, except under extreme conditions of time and enzyme concentration affording or supplying a hydrolytic factor which assists the beta amylase hydrolysis.

It would appear that the theories for beta amylase action, proposed by Cleveland and Kerr and by Swanson and Cori, more adequately interpret all pertinent data than alternative proposals in the past.

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Mechanism of Decomposition of Polythionates and Formation of a Sulphinic Acid

By the use of the radioactive isotope of sulphur, ^{35}S, the following reactions have been investigated.

(*a*) By the application of different chemical reactions, Olav Foss[1,2] has made it probable that the reaction between sulphite and tetrathionate consists in a displacement of a thiosulphate group by a sulphite ion as given below:

$$-SO_3—S—S—SO_3^- + {}^*SO_3^{--} \rightarrow -SO_3—S—{}^*SO_3^- + S_2O_3^{--}. \quad (A)$$

We have been able to corroborate this view by the following experiments.

Active sodium sulphite was treated for about one hour in solution with potassium tetrathionate in excess (exp. No. 1, 1 : 4; exp. No. 2, 1 : 2). The value of *p*H was about 6·1, and the temperature 20° C. After the reaction had taken place, the solution was strongly acidified with hydrochloric acid. The sulphur dioxide evolved was absorbed in a potassium triiodide solution by passing a stream of nitrogen (fraction I). Free sulphur was filtered off, washed and converted to sulphuric acid by prolonged boiling with nitric acid (fraction II). From both fractions barium sulphate was precipitated. In experiment No. 2, the sulphur in the remaining part was converted into sulphate and precipitated as barium sulphate (fraction III). A search for the activity gave the following results: fraction II was completely inactive. In both experiments fraction I contained about 3 per cent of the original activity, while the balance was found in fraction III. The reaction thus follows the course predicted by O. Foss.

The small activity found in the sulphur dioxide fraction may be due to a certain reversibility of reaction (*A*), as we have made sure that all sulphite had reacted.

(*b*) By the investigation of the reaction between active sulphite and potassium pentathionate we have obtained similar, although more complicated results. Foss's assumption that the reaction between sulphite and polythionates is simply an exchange of a sulphite ion with a thiosulphate ion is again in complete agreement with the experimental facts.

(*c*) Formation of sulphinic acid from the corresponding sulphonyl chloride:

$$C_7H_7SO_2Cl + SO_3^{--} + 2OH^- \rightarrow C_7H_7SO_2^- + Cl^- + SO_4^{--} + H_2O. \quad (B)$$

p-Toluene sulphonyl chloride was boiled with active sulphite in the presence of sodium carbonate. The solution was acidified with hydrochloric acid, and the sulphinic acid extracted with ether. The sulphate ions were precipitated as barium sulphate. The acid proved to be completely inactive, while the barium sulphate contained all the activity. We thus find that the sulphonyl sulphur remains bound to the carbon atom, which is in complete accordance with classical views.

Further studies will be carried out on these lines, and a detailed report will appear in *Acta chemica scandinavica*.

We wish to thank N. Hofman-Bang for having supplied us with tetrathionate and pentathionate, and K. Zerahn for help in measuring the activities.

J. A. CHRISTIANSEN
W. DROST-HANSEN

University Institute of Physical Chemistry,
Copenhagen. June 1.

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Soil Copper Deficiency in County Offaly, Ireland

On a farm where a feeding experiment in connexion with phosphate deficiency in pasture herbage was in progress, a heifer showing extreme emaciation and excessive scouring was brought to my notice. The scour, which was almost continuous, was thin and watery, green to black in colour with numerous small bubbles, and had persisted for a period of more than two months. It started in January while the heifer was fed on old meadow hay of very poor quality grown on peaty soil, moist sugar pulp and a small amount of herbage consumed from a rather bare moory pasture. The soil on the farm, which appears to be comparable with that on which successfully treated similar cases are reported elsewhere[1–3], is composed mainly of peat resting on marl, and is slightly acid in reaction.

Parasitic infestation was first suspected, and the well-known remedies for parasitic gastro-enteritis and liver fluke were administered with negative results. It was then decided to give copper treatment, and a solution was made by dissolving one ounce of copper sulphate in a pint of water. One ounce of this solution was mixed with a pint of water and given as a drench. A second drench was given after an interval of one day.

Results were forthcoming almost immediately: scouring ceased, and the fæces assumed normal consistency. After an interval of three weeks, slight scouring again occurred. A drench given at this stage gave results similar to those experienced in the first instance. The heifer has considerably improved in health and body condition.

J. O'DONOVAN

County Committee of Agriculture,
Tullamore, Offaly.

[1] Frens, *Tydschr. Diergeneesk*, **68**, 763 (1941).
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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 31

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Sir Geoffrey Heyworth: "The Use of Statistics in Business".

UNIVERSITY OF LONDON (in the Chemistry Theatre, University College, Gower Street, London, W.C.1), at 5.15 p.m.—Prof. H. J. Emeléus, F.R.S.: "The Chemistry of the Transuranics and other Newly-discovered Elements".* (Further Lectures on November 7 and 14.)

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Dr. P. C. Goldmark: "The C.B.S. Colour Television System in the United States".

ROYAL GEOGRAPHICAL SOCIETY (at Kensington Gore, London, S.W.7), at 5.30 p.m.—"Subantarctic Weather Station" (Films with commentary by Mr. W. A. Scholes).

CHEMICAL SOCIETY, OXFORD SECTION (in the Physical Chemistry Laboratory, Oxford), at 8.15 p.m.—Prof. E. Bright Wilson, Jr.: "Microwave Spectroscopy" (Alembic Club Lecture).

Tuesday, November 1

INSTITUTE OF PHYSICS, SCOTTISH BRANCH (at University College, Dundee), at 4.30 p.m.—Prof. P. I. Dee, F.R.S.: "Recent Advances in Nuclear Physics".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Prof. E. K. Rideal, F.R.S.: "Some Aspects of Heterogeneous Catalysis". (Further Lectures on November 8, 15 and 22.)

INSTITUTION OF ELECTRICAL ENGINEERS, CAMBRIDGE RADIO GROUP (at the Cavendish Laboratory, Cambridge), at 8.15 p.m.—Mr. D. W. Fry: "Some Recent Advances in the Design of High-Energy Electron Accelerators".

Wednesday, November 2

ASLIB (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Papers by Dr. Alexander King and Dr. D. C. Martin describing the work in progress as a result of the Royal Society's Scientific Information Conference in 1948.

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY, SOCIAL PHILOSOPHY SECTION (at the Portico Library, Mosley Street, Manchester), at 5.30 p.m.—Dr. F. D. Wilkins: "Freedom and the Management of the Scientist".

PHYSICAL SOCIETY, COLOUR GROUP (at the Institute of Ophthalmology, Judd Street, London, W.C.1), at 5.30 p.m.—Dr. A. A. Kruithof (Eindhoven): "Some Experiments and Considerations concerning Chromatic Adaptation".

ROYAL MICROSCOPICAL SOCIETY, BIOLOGICAL SECTION (in the Hastings Hall, B.M.A. House, Tavistock Square, London, W.C.1), at 6 p.m.—Dr. G. A. Harrison and Mr. M. G. L. Curties: "Inexpensive Phase Microscopy".

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.45 p.m.—Papers on "Some Recent Advances in Water Examination".

BRITISH INSTITUTION OF RADIO ENGINEERS, MERSEYSIDE SECTION (at the Accountants' Hall, Derby Square, Liverpool), at 7 p.m.—Mr. A. L. Whitwell: "Electronics in Aircraft Design".

INSTITUTE OF WELDING MANCHESTER AND DISTRICT BRANCH (in the Reynolds Hall, College of Technology, Manchester), at 7 p.m.—Mr. E. V. Beatson: "The Joining of Coated Metals".

CHEMICAL SOCIETY, EIRE SECTION (in the Department of Chemistry, University College, Dublin), at 7.45 p.m.—Mr. J. G. Belton: "Some Biologically Active Phenazine Derivatives".

Wednesday, November 2—Friday, November 4

SCIENTIFIC INSTRUMENT MANUFACTURERS' ASSOCIATION, ELECTRONICS SECTION (at the Examination Hall, Queen Square, London, W.C.1).—Symposium on "Electronics".

Thursday, November 3

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. T. B. Grimley: "The Contact between a Solid and an Electrolyte"; Mr. J. R. Whitehead: "Surface Deformation and Friction of Metals at Light Loads".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Mr. Seton Gordon: "Wild Life in the Highlands and Islands". (Further Lectures on November 10 and 17.)

CHEMICAL SOCIETY, SHEFFIELD SECTION (joint meeting with the UNIVERSITY CHEMICAL SOCIETY, in the Chemistry Lecture Theatre, The University, Sheffield), at 5.30 p.m.—Dr. C. W. Suckling: "Some Aspects of the Organic Chemistry of Fluorine".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Dr. H. I. Andrews: "Electrical Weighing" (Measurements Section Paper).

UNIVERSITY OF LONDON (in the Department of Civil, Mechanical and Chemical Engineering, King's College, Strand, London, W.C.2), at 5.30 p.m.—Mr. J. K. T. L. Nash: "The Elements of Soil Mechanics in Theory and Practice".* (Further Lectures on November 10, 17 and 24.)

CHEMICAL SOCIETY, BRISTOL SECTION (joint meeting with the ROYAL INSTITUTE OF CHEMISTRY and the SOCIETY OF CHEMICAL INDUSTRY, in the Department of Chemistry, The University, Bristol), at 7 p.m.—Prof. C. A. Coulson: "What is a Chemical Bond?"

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.15 p.m.—Scientific Papers.

TEXTILE INSTITUTE (at 16 St. Mary's Parsonage, Manchester), at 7.15 p.m.—Mr. W. P. Hazeldine and Dr. L. Klein: "Textile Trade Wastes and their Treatment".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7.30 p.m.—Mr. H. Ritter: "Hydraulic Analogy of Compressible Flow—a Substitute for the High Speed Tunnel".

Friday, November 4

PHYSICAL SOCIETY (at the Science Museum, Exhibition Road, London, S.W.7), at 5 p.m.—Dr. G. M. B. Dobson, F.R.S.: "Physics and the Atmosphere". (Fifth Charles Chree Address.)

ROYAL STATISTICAL SOCIETY, LONDON GROUP of the INDUSTRIAL APPLICATIONS SECTION (at the E.L.M.A. Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 6 p.m.—Symposium on "The Repeatability and Reproducibility of Test Results".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. A. V. Hill, F.R.S.: "The Dimensions of Animals and their Muscular Dynamics".

Saturday, November 5

INSTITUTE OF PHYSICS, SOUTH WALES BRANCH (at University College, Swansea), at 2 p.m.—Dr. F. C. Toy: "Some Applications of Classical Physics in the Textile Industry".

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Major Maxwell Knight: "Some Unsolved Problems of Natural History".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

CHAIR OF MEDICAL PHYSICS—The Registrar, The University, Leeds 2 (November 4).

TESTING OFFICER to take charge of performance-testing of dairy plant and equipment under laboratory and field conditions, and an EQUIPMENT ENGINEER to be responsible for the general design of a wide variety of specialized laboratory apparatus, instruments and equipment—The Secretary, National Institute for Research in Dairying, Shinfield, Reading (November 5).

LECTURER IN PHYSICS at the Brighton Technical College—The Education Officer, 54 Old Steine, Brighton (November 5).

LIBRARIAN of the Torry Research Station, Aberdeen (of the Directorate of Food Investigation)—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting G.356/49BN (November 7).

FOREMAN COLLECTOR OF BOTANICAL SPECIMENS and a COLLECTOR OF BOTANICAL SPECIMENS, in the Education Officer's Department (to work from the Botany Scheme Offices, Avery Hill, Eltham, S.E.9)—The Education Officer (EO/Estab.), County Hall, Westminster Bridge, London, S.E.1 (November 11).

ASSISTANT LECTURERS (2) IN THE DEPARTMENT OF DAIRYING, one to give instruction in the laboratory control of dairying processes, the other to specialize in dairy engineering—The Registrar, The University, Reading (November 14).

SENIOR LECTURER and a LECTURER IN BIOCHEMISTRY—The Registrar, University of Sydney, Sydney, N.S.W., Australia (November 30).

CHAIR OF NATURAL HISTORY, United College, St. Andrews—The Secretary, The University, St. Andrews (January 31).

LECTURER IN INORGANIC CHEMISTRY to B.Sc. Degree standard—The Principal, Sir John Cass Technical Institute, Jewry Street, London, E.C.3.

ASSISTANT LECTURER AND DEMONSTRATOR IN THE BOTANY DEPARTMENT—The Secretary, Royal Technical College, Glasgow.

ELECTRICAL ENGINEER IN THE ELECTRICAL DEPARTMENT, Gold Coast Colony—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27323/16.

ENGINEERS for investigations in connexion with the harvesting of under-water seaweed—The Head of the Engineering Division Institute of Seaweed Research, Inveresk Gate, Musselburgh, Midlothian.

SENIOR ASSISTANT and LECTURERS IN THE DEPARTMENT OF APPLIED CHEMISTRY—The Secretary, Northampton Polytechnic, St. John Street, London, E.C.1.

ASSISTANT CONTROLLERS OF TELECOMMUNICATIONS (Engineering), Federation of Malaya—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27123/8.

PHYSICAL CHEMIST to take part in the environmental side of the M.R.C. Department for Research in Industrial Medicine—The Physician in Charge, Department for Research in Industrial Medicine, London Hospital, Whitechapel, London, E.1.

LECTURER IN AGRICULTURAL CHEMISTRY, to teach Animal Nutrition and to assist in Demonstrating in the Laboratories—The Principal, Harper Adams Agricultural College, Newport, Shropshire.

RESEARCH OFFICERS (2, temporary) at the Oil Palm Research Station, Benin, Nigeria—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1.

ENTOMOLOGIST to conduct entomological surveys in the areas selected for development in the Volta River area, Gold Coast—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting 27215/230.

LECTURER IN CHEMISTRY (including Biochemistry) at the School of Chemistry and Pharmacy, Royal Medical College, Baghdad—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting MN.22783/3F.

TECHNICIAN IN THE DEPARTMENT OF GEOLOGY—The Secretary, University College, Gower Street, London, W.C.1, quoting Geology/2.